NORTH ATLANTIC TREATY ORGANIZATION

SCIENCE AND TECHNOLOGY ORGANIZATION

AC/323(SAS-098)TP/553

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STO TECHNICAL REPORT **TR-SAS-098**

Operations Research / Operations Analysis Orientation Course Curriculum for NATO Nations

(Programme d'initiation à la recherche / l'analyse opérationnelle pour les pays de l'OTAN)

This Report documents the products of SAS-098 which include a set of instructional modules and supporting case studies to demonstrate the value of analysis in senior officer decision-making.

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The NATO Science and Technology Organization

Science & Technology (S&T) in the NATO context is defined as the selective and rigorous generation and application of state-of-the-art, validated knowledge for defence and security purposes. S&T activities embrace scientific research, technology development, transition, application and field-testing, experimentation and a range of related scientific activities that include systems engineering, operational research and analysis, synthesis, integration and validation of knowledge derived through the scientific method.

In NATO, S&T is addressed using different business models, namely a collaborative business model where NATO provides a forum where NATO Nations and partner Nations elect to use their national resources to define, conduct and promote cooperative research and information exchange, and secondly an in-house delivery business model where S&T activities are conducted in a NATO dedicated executive body, having its own personnel, capabilities and infrastructure.

The mission of the NATO Science & Technology Organization (STO) is to help position the Nations' and NATO's S&T investments as a strategic enabler of the knowledge and technology advantage for the defence and security posture of NATO Nations and partner Nations, by conducting and promoting S&T activities that augment and leverage the capabilities and programmes of the Alliance, of the NATO Nations and the partner Nations, in support of NATO's objectives, and contributing to NATO's ability to enable and influence security and defence related capability development and threat mitigation in NATO Nations and partner Nations, in accordance with NATO policies.

The total spectrum of this collaborative effort is addressed by six Technical Panels who manage a wide range of scientific research activities, a Group specialising in modelling and simulation, plus a Committee dedicated to supporting the information management needs of the organization.

- AVT Applied Vehicle Technology Panel
- HFM Human Factors and Medicine Panel
- IST Information Systems Technology Panel
- NMSG NATO Modelling and Simulation Group
- SAS System Analysis and Studies Panel
- SCI Systems Concepts and Integration Panel
- SET Sensors and Electronics Technology Panel

These Panels and Group are the power-house of the collaborative model and are made up of national representatives as well as recognised world-class scientists, engineers and information specialists. In addition to providing critical technical oversight, they also provide a communication link to military users and other NATO bodies.

The scientific and technological work is carried out by Technical Teams, created under one or more of these eight bodies, for specific research activities which have a defined duration. These research activities can take a variety of forms, including Task Groups, Workshops, Symposia, Specialists' Meetings, Lecture Series and Technical Courses.

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Operations Research / Operations Analysis Orientation Course Curriculum for NATO Nations

(STO-TR-SAS-098)

Executive Summary

SAS-098 was tasked to design a set of instructional modules to demonstrate the value of various Operations Research and Operational Analysis (OR/OA) analytical tools in decision-making to the non-analyst. The annex to this report provides these modules categorized by application area. In addition to inclusion in this report's annex, instructional modules are posted on the ACT website (https://transnet.act.nato.int/WISE/NATOAnalys) for NATO instructors and analysts to review and download for use. Specific delivery venues may be in NATO senior executive exercises, an STO Lecture Series, inclusion in existing NATO schools and courses, and by NATO Nations within their national course offerings. Post-study, it is envisioned that instructors may wish to use the templates offered here to develop case studies on future operations so that the bank of instruction will grow, be timely, and relevant.

STUDY'S OBJECTIVE

Commanders and their staffs must have an appreciation for the potential of OR/OA analytical tools to fully leverage their potential. This study designs a set of instructional modules to demonstrate to non-analysts how OR/OA is useful in their decision-making and operational assessment challenges.

SCOPE, ORGANIZATION, AND FORMAT

We select case studies as the basic format for the instructional modules. Each case study has a real-world example to demonstrate the relevancy of the operational analysis techniques to decision-makers. The team identified six application areas to consider for case study generation. These application areas are strategic planning, support of military operations, transforming armed forces, logistics and acquisition, scheduling, and other. The "strategic planning" application area addresses case studies of national or strategic importance. "Support of military operations" application area focuses on case studies dealing with decisions or operations at the operational level usually while the operations are on-going or being planned. The application area title "Transforming Armed Forces" deals with case studies related to re-shaping force structures, processes, or bases. "Logistics and acquisition" application area contains decision related cases dealing with supply, support, or the procurement of forces. "Scheduling" deals with cases dealing with the efficient employment of forces or logistics that have an operational impact. The "other" application area allows for the introduction of basic operational analysis tools and for case studies not falling neatly into any other application category respectively.

Individual case study modules have three components; an instructional module summary, the actual presentation material, and any background reading material for future instructors and executives. Each instructional module summary and presentation has a standard format. The instructional module summary includes the title of the case study, the developer's name and organization, presentation length in time, learning objectives, a brief outline, any additional materials, and delivery methods. In general, the presentation has two parts: a ten to twenty minute summary for a general officer, flag officer, or executive decision-makers; and a second part for more junior staff officers or analysts wishing more detail. Each presentation follows a template, with the understanding that future presenters may modify it to suit their audience.

Programme d'initiation à la recherche / l'analyse opérationnelle pour les pays de l'OTAN

(STO-TR-SAS-098)

Synthèse

Le SAS-098 avait pour mission de concevoir un ensemble de modules d'instruction démontrant la valeur de différents outils analytiques de recherche et d'analyse opérationnelles (OR/OA) dans la prise de décision des non-analystes. L'annexe au présent rapport présente ces modules classés par domaine d'application. Par ailleurs, les modules d'instruction sont placés sur le site Internet (https://transnet.act.nato.int/WISE/NATOAnalys) pour que les instructeurs et analystes de l'OTAN les lisent, les téléchargent et les utilisent. Ces modules sont susceptibles d'être présentés lors d'exercices majeurs de l'OTAN ou dans une série de conférences de la STO ; ils peuvent être inclus dans les cours et écoles de l'OTAN existants et les cours nationaux délivrés par les pays de l'OTAN. Après l'étude, les instructeurs auront la possibilité d'utiliser les modèles proposés ici pour élaborer des études de cas sur des opérations futures, afin que la banque d'instructions s'étoffe, reste d'actualité et demeure pertinente.

OBJECTIF DE L'ETUDE

Les commandants et leurs états-majors doivent mesurer le potentiel des outils analytiques d'OR/OA pour les exploiter pleinement. La présente étude établit un ensemble de modules d'instruction dans le but de démontrer aux non-analystes en quoi l'OR/OA est utile à leur prise de décision et aux difficultés d'évaluation opérationnelle.

PORTEE, STRUCTURE ET FORMAT

Le format de base des modules d'instruction est l'étude de cas. Chaque étude de cas s'accompagne d'un exemple du monde réel afin de prouver aux décideurs la pertinence des techniques d'analyse opérationnelle. L'équipe a identifié six domaines d'application à étudier pour la production des études de cas. Ces domaines d'application sont la planification stratégique, le soutien des opérations militaires, la transformation des forces armées, la logistique et l'acquisition, la programmation et une catégorie appelée « autres ». Le domaine d'application « planification stratégique » concerne les études de cas d'importance nationale ou stratégique. Le domaine d'application « soutien des opérations militaires » se concentre sur les études de cas ayant trait à des décisions ou opérations au niveau opérationnel, d'ordinaire pendant le déroulement ou la planification des opérations. Le domaine d'application « transformation des forces armées » s'intéresse aux études de cas liées à la modification des structures, processus ou bases des forces armées. Le domaine d'application « logistique et acquisition » contient les cas relatifs aux décisions de fourniture, de soutien ou d'approvisionnement des forces. Le domaine « programmation » regroupe les études de cas qui traitent de l'utilisation efficace des forces ou de la logistique ayant un impact opérationnel. Le domaine d'application intitulé « autres » permet de présenter des outils d'analyse opérationnelle de base et des études de cas qui n'entrent pas exactement dans une autre catégorie d'application.

Les modules des études de cas se composent de trois parties : un résumé du module d'instruction, la présentation proprement dite et des références bibliographiques pour les futurs instructeurs et cadres. Chaque résumé et présentation des modules d'instruction a un format standard. Le résumé du module d'instruction inclut le titre de l'étude de cas, le nom et l'organisme du rédacteur, la durée de la présentation,

les objectifs d'apprentissage, une brève description, des documents complémentaires et les méthodes d'exposé. En général, la présentation tient en deux parties : un résumé en dix ou vingt minutes destiné à un officier général, commandant ou cadre dirigeant et une seconde partie pour les officiers de rang inférieur ou les analystes souhaitant plus de détail. Chaque présentation repose sur un modèle, étant entendu que les futurs présentateurs peuvent le modifier pour s'adapter à leur public.

Chapter 1 – INTRODUCTION AND REPORT OUTLINE

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1.1 STUDY OBJECTIVES

The charter of SAS-098 Task Group 043 was to design a set of instructional modules to demonstrate to the non-analyst the value provided by various Operations Research and Operational Analysis (OR/OA) analytical tools in decision making. Annex A provides these modules categorized by application area. The modules are also available through the NATO Analysis Community of Interest website at https://transnet.act.nato.int/WISE/NATOAnalys. These modules are developed for educators, trainers, and practicing analysts for presentation to individual decision makers and their staffs, or integration into existing NATO courses with the goal of inspiring greater use of operational analysis NATO-wide.

The modules' primary audience are decision-makers at the flag and executive civilian level.

This report serves as one delivery venue of the instruction modules and this chapter provides an outline of the report. Future case study development may be aided by the report's display of general format and templates agreed upon by Member Nations.

1.2 BACKGROUND

As a professional group, the military personnel of NATO Nations receive high-level, quality education from a wide range of academic disciplines throughout their career. The need for high-quality analysis to support decision-making in military acquisition, in force development, in force employment and in management of the national military and NATO organizations compels continued emphasis on scientific rigor. OR/OA provides evidence-based support to decision-making with an emphasis on this scientific rigor. Deepening the understanding of the contributions OR/OA analytical tools provide will help Commanders and their staffs to more fully leverage their potential. This study designs a set of instructional modules to demonstrate to non-analysts how OR/OA is useful in their decision-making and operational assessment challenges.

1.3 STUDY TEAM COMPOSITION AND ACTIVITIES

The SAS-098 study team includes participants from eight Nations listed in the Membership List. The nature of the study allowed for both physical and virtual (web) meetings to scope the material to the intended audience, develop application areas of interest, agree upon case study composition and format, and begin to develop the material. In total, seven physical meetings and thirteen web-based meeting were held as listed in Table 1-1. In addition to these meetings, a working web site was established at the Naval Postgraduate School to collect draft module submissions and allow team members to review submitted work independently.

Table 1-1: SAS-098 RTG-043 Meeting Activity from 16 September 2011 to 27 September 2013.

Meeting Date	Type	Location	Comments
16 September 2011	Physical Meeting	CSO, Neuilly-sur-Seine, France	Exploratory Meeting
18 January 2012	Virtual Meeting	Web	Web Working site established
21 February 2012	Physical Meeting	Brno, CHZ	
22 March 2012	Virtual Meeting	Web	
2-3 May 2012	Physical Meeting	Ottobrunn, DEU	Application areas and Instructional templates finalized
15 June 2012	Virtual Meeting	Web	
11 July 2012	Virtual Meeting	Web	
22 August 2012	Virtual Meeting	Web	
19 September 2012	Virtual Meeting	Web	
16-17 October 2012	Physical Meeting	Monterey, USA	Demonstrated several case studies to SAS Panel members and flag officers, case study list finalized
27 November 2012	Virtual Meeting	Web	
23 January 2013	Virtual Meeting	Web	
20 February 2013	Virtual Meeting	Web	
20 March 2013	Virtual Meeting	Web	
17 April 2013	Virtual Meeting	Web	
10 May 2013	Virtual and Physical Meeting	Web and Monterey	Proposed several case studies as final versions
10-11 June 2013	Physical Meeting	Munich, DEU	Reviewed final report, finalized several more case studies, and structured ACT website for receipt of case studies
7 August 2013	Virtual Meeting	Web	
26-27 September 2013	Physical Meeting	Ankara, Turkey	Case study delivery (beta), review final briefing, review final report

1.4 STUDY OUTLINE

The chapters of this report provide information on the development of the case study modules and templates to use for future development. This chapter introduces the study's objectives, discusses the background, shows the study team activity, and provides the remaining outline. The following table (Table 1-2) provides the remaining chapters' title and a brief description of their content.

Table 1-2: Report Organization by Chapter.

Chapter	Title	Contents
1	Introduction and Report Outline	Overview
2	Scope and Case Studies Focus	Past Studies, intended audience, case study focus, application areas and description of topics developed, the OA tools matrix
3	Instructional Module Templates	Composition of the three-part case study: module composition introduction; the instructional module summary; and the presentation template
4	Delivery and Archiving Recommendations	Archived locations of case studies instruction material and alternative delivery venues and summary
Annex	Application Areas with Supporting Curriculum	Individual Case Study Modules Developed

Chapter 2 – SCOPE AND CASE STUDIES FOCUS

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2.1 REVIEW OF OPERATIONAL ANALYSIS STUDIES

Several SAS studies have addressed or are addressing effective implementation of operational analysis in NATO operations. As summarized below, most of these studies focus on aiding analysts in their efforts to integrate with NATO planning and execution processes.

A review of the SAS studies summaries in Table 2-1 show these studies and initiatives are valuable resources for a NATO operational analyst. They do not, however, address the value of operational analysis from a senior decision maker's viewpoint (the SAS-098 study group tasking).

Table 2-1: Past SAS Studies and Efforts Addressing Employment of Operational Analysis.

Project	Date	SAS Study #	Summary
Operational Analysis Course for Deploying Analysts	In Progress	101	This follow-on effort to SAS-89 is developing and delivering a short course to deploying NATO analyst.
Operational Analysis Support to NATO Operations	Aug 2012	089	SAS-089 "Operational Analysis (OA) Support to NATO Operations" elaborates a recommendation of an organizational structure, common procedures and training that would improve effectiveness, interoperability, and sustainability of OA support to operations in both NATO and national static and deployed HQs. The report describes an employment concept for OA support to NATO operations. It outlines the roles and responsibilities of OA, describes where operational analysts should be positioned in deployed HQs, and makes proposals with regard to the function and role of a NATO reach back capability, as well as qualification, selection and training of OA personnel. It identifies gaps between the current and desired situation and provides recommendations to fill these gaps and for the implementation of the proposed concept.
NATO Guide for Judgment-Based Operational Analysis in Defence Decision-Making	Jun 2012	087	A Guide consisting of three volumes: an analyst-oriented document (the "Code of Best Practice for 'Soft' Operational Analysis"), a client-oriented document, and a brief summarizing brochure for high-level, 'executive' decision-makers.

Project	Date	SAS Study #	Summary
NATO Guide for Judgment-Based Operational Analysis in Defence Decision-Making (cont'd)	Jun 2012	087	The purpose of the Guide is to create an understanding of what judgment-based OA is; to clarify what judgment-based OA can do to help address problematic situations; what people can expect from it in that respect; and to provide guidance on how a judgment-based OA study should be carried out to maximize the validity, credibility and acceptance of the study and its outcomes.
NATO Operations Assessment: A Case Study Based on Planning for Transition in Afghanistan	Apr 2012	091	A case study on transition operations in Afghanistan.
The Human Environment Analysis Reasoning Tool (HEART) – Incorporating Human and Social Sciences into NATO Operational Planning and Analysis	Nov 2011	074	The paper provides an outline description and user guide for the Human Environment Analysis Reasoning Tool (HEART) which helps military staff and analysts understand the human and social environment, develop effective courses of action, and make use of appropriate analysis methods. HEART can be used to support early phases of operational planning, as a training resource and to improve the representation of the human and social environment in exercises and experiments.
Long Range Forecasting of the Security Environment	Apr 2011	088	The theme for the SAS-088 Specialists Meeting was "Long Range Forecasting of the Security Environment". The meeting aimed to establish a forum to review national and international perspectives, methods and supporting analytical techniques for long range foresight. To achieve these goals the meeting was organized into three sessions each structured with a Keynote presentation, a number of papers, a discussion period, and finally a syndicate session addressing a specific topic raised in the session. These three sessions covered: 1) Methodology – Various approaches, methods and tools for performing medium-to-long term forecasts of the future security environment intended to improve defence policy and planning within NATO, and the assumptions, limitations and bias that may challenge the conduct of effective security analysis. 2) Process – How uncertainty is accounted for within various foresight approaches and its effect on assessment, validation and measures of robustness, and ways to respond to uncertainty in the development of national defence and security requirements. 3) Integration with Policy – How Allied Nations conduct and implement foresight generation into policy formulation and decision-making.

Project	Date	SAS Study #	Summary
Analytical Support to Defence Transformation	Apr 2010	081	The SAS-081 Symposium on "Analytical Support to Defence Transformation" was held in Sofia, Bulgaria, 26-28 April 2010. It aimed to provide a forum for the analytical community to address and respond to NATO's military transformation needs. It brought together 90 participants from 19 NATO and Partner Nations, and featured 33 presentations, structured around five main themes: general analytical issues; defence planning; capability development; concept development and experimentation; and current operations.
Analytical Support to Defence Transformation	Apr 2005	055	The Studies, Analysis and Simulation (SAS) Panel conducted a three-day symposium (SAS-055/RSY) on "Analytical Support to Defence Transformation". It intended to bridge the gap between the operational and research communities who are responsible for accomplishing the Transformation which NATO seeks and the analytical community who are charged to support the design and assessment of future force effectiveness. Five important issues were discussed: 1) The conditions, which motivate the need for, and keen interest in NATO Transformation; 2) Capability Based Planning; 3) Effects Based Operations and highlighted the need for considering a much broader set of factors than those considered by recent military operational analysis; 4) Network-Enabled Capabilities (NEC); and 5) Concept Development and Experimentation.
Operational Analysis Support to NATO IFOR/SFOR Operations	Mar 1999	003	The document records the proceedings of a Symposium held in June 1997 addressing actual Operations Analysis (OA) support to IFOIUSFOR operations. A total of 14 papers were presented by analysts who were deployed in theatre during the deployment of IFOR, by analysts involved in logistic planning, cost estimating and C31 issues, and by analysts involved in lessons learnt teams. In addition a forward looking presentation was given concerning in-theatre support to SFOR.

2.2 CASE STUDY APPROACH

Given the time constraints and demands for the attention of senior NATO leaders, the group's consensus is that the instructional material derived by this study's effort (and follow-on contributions) must be able to be delivered in no more than twenty minutes, be executive in nature, and be relevant to that specific NATO leader. Therefore, we selected a historical case study approach organized by application areas for instructional material development.

2.2.1 Relevance

The team identified six application areas to consider for case study generation. These application areas are strategic planning, support of military operations, transforming armed forces, logistics and acquisition, scheduling, and other. The "strategic planning" application area addresses case studies of national or strategic importance. "Support of military operations" application area focuses on case studies dealing with decisions or operations at the operational level usually while the operations are on-going or being planned. The application area titled "Transforming Armed Forces" deals with case studies related to re-shaping force structures, processes, or bases. "Logistics and acquisition" application area contains decision-related cases dealing with supply, support, or the procurement of forces. "Scheduling" deals with cases dealing with the efficient employment of forces or logistics that have an operational impact. The "other" application area allows for introduction of basic operational analysis tools and for case studies not falling neatly into any other application category respectively.

The objective of these application areas is for presenters to search under relevant topics that will interest the senior leader they intend to provide instruction. For example, if a presenter knows that the audience will be NATO Commander in charge of employment of troops, the presenter may look in the application areas of Logistics, Scheduling, and Support for Military Operations to find applicable case studies. Once a relevant case study is found, the presenter may modify it to suit the specific needs of the flag or general officer.

2.2.2 Concise Presentation at the Executive Level

As discussed in more detail in Chapter 3, the structure of the instructional presentation material is designed to quickly demonstrate the material's relevance to the senior leader through an actual case study with a decision challenge for a senior leader. The executive portion of the material is no more than 10 – 15 slides, with the option of more detailed analytical information following the executive presentation to provide the staff and analysts supporting the Commander.

In addition, these case studies may be useful in NATO Member Nations' national schools to provide studies for specific operational analysis tools. Table 2-2 shows a matrix that cross-references application areas with specific operational analysis disciplines.

Table 2-2 is meant to be a living document, growing to accommodate new case studies after the formal conclusion of SAS-098. As operational analysts continue to contribute to NATO operations, the potential exists for more case studies to be added using our study's common template saved in a location electronically to make them accessible to all NATO members. Chapter 3 discusses this common structure of an Instructional Module to provide a summary of the material and the presentation material with a specific format.

Table 2-2: Application Area and OA Tool Case Study Cross Reference.

	Analytics and Assessment	Probability Statistics Data Analysis	Optimization	Decision Analysis and Game Theory	Soft OA	Simulation	Data Visualization
Strategic Planning (J5)	Strategic Analysis and EBAO			Peace Support Operation Planning			
Support for Military Operations (J3/J5)	Improved Situational Awareness (Correlation and Pattern) Improved Situational Awareness (Descriptive Statistics)	General Officer Targeting; Persistent Threat Detection System Improved Situational Awareness (Correlation and Pattern) Improved Situational Awareness (Descriptive Statistics)	Intra-theater Air Lift	Peace Support Operation Planning	Chernoff Faces		Persistent Threat Detection System Chernoff Faces
Transformation (J4/J5)	Visual Analytics in Operational Capability Requirements Evaluation			Base Realignment and Closure			

	Analytics and Assessment	Probability Statistics Data Analysis	Optimization	Decision Analysis and Game Theory	Soft OA	Simulation	Data Visualization
Logistics and Acquisition (J4/J8/J9)		Cost Estimation for Major Defence Systems (LPD ship)	Replenishment at Sea DEU Out Planning Intra-theater Lift Stockpile Planning Guidance	Cost Estimation for Major Defence Systems (LPD ship)			
Scheduling (J3)			Replenishment at Sea DEU Out Planning				
Other	Operation Eagle Claw	Operation Eagle Claw Probability and Decision Trees: Challenger Space Shuttle		Probability and Decision Trees: Challenger Space Shuttle	Expeditionary Operations (Morphological Analysis)	Operation Eagle Claw	
Overview	Making Better Decisions with operational Analysis: An Overview	Making Better Decisions with Operational Analysis: An overview	Making Better Decisions with Operational Analysis: An overview	Making Better Decisions with Operational Analysis: An overview	Making Better Decisions with Operational Analysis: An overview	Making Better Decisions with Operational Analysis: An overview	Making Better Decisions with Operational Analysis: An overview

Chapter 3 – INSTRUCTIONAL MODULE TEMPLATES

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3.1 NEED FOR STANDARD FORMAT

The study participants recognized the need for a standard format to develop and present case studies early in the SAS-098 effort. In addition to allowing a consistent development method for this study, standard instructional templates suggest an efficient way to capture new case studies as they occur in the future. A case study composed of three elements: the Instructional Module Summary, the presentation with talking notes, and any reference or reading material. The Instructional Module format quickly communicates to an instructor the main theme of the case study. The presentation format quickly demonstrates the relevancy and importance of the case study to a senior decision-maker. This is particularly addressed in the "Overview" slide discussed below and shown in Figure 3-1. The presentation format also allows for more detail to be given to staff and/or analysts interested in the analytical tool used in the case study. Finally, if there is reference material available, a third element of the case study can be included for instructor and student use.

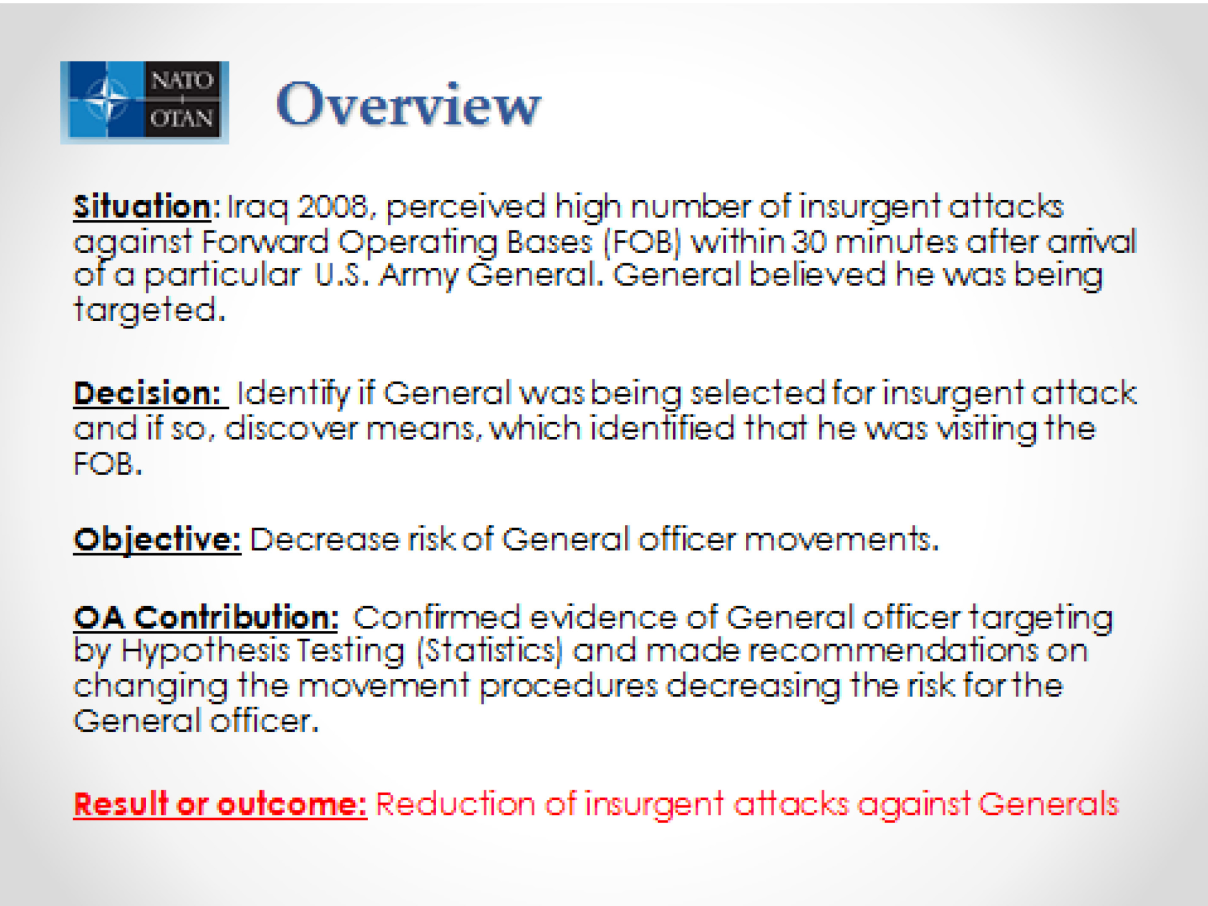


Figure 3-1: Summary Slide.

3.2 INSTRUCTIONAL MODULE SUMMARY

The first component – the instructional module summary – consists of eleven parts which constitute a brief overview of the specific lecture. It includes the title of the case study, the developer's name and organization, presentation length in time, learning objectives and corresponding outcomes, a brief content outline, any additional materials (e.g. required pre-readings), delivery methods, and discussion questions.

Table 3-1 illustrates this standard format.

Table 3-1: Instructional Module Summary Standard Format.

Title	From Concept to Operational Method for Domestic Operations, The Impact of Strategic Analysis: Canada Command Effects Based Approach to Operations
Faculty Name(s)	Brad Gladman, DRDC CORA, Ottawa ON, Canada
Length	60 – 90 minutes
Learning Objectives	Understand the value of the distinct capability of strategic analysis. Appreciate the relationship of strategic analysis to competent operational planning in achieving the Commander's intent. Appreciate the need for an appropriate reporting relationship, and other essential requirements, in order to realize the potential of strategic analysis in decision-support.
Outcomes	As the result of this module, participants will be able to: • Understand the value of the distinct capability of strategic analysis in decision-support. • Understand how strategic analysis can complement competent operational planning in the development of a clear operational method, which in this case was used to change other government department thinking about the 'effects' the military can generate in various crises as part of a Whole of Government approach. • Understand what strategic analysis requires in order to be successful in any organization it supports.
Content Outline	Case Study: Canada Command Effects Based Approach to Operations. Vague concept to operational method. Concept tailored to domestic/continental operating environment as part of a Whole of Government approach. Summary of strategic analysis requirements for success in any organization.

Materials	List Required Pre-Readings: Dr. Brad Gladman and Dr. Peter Archambault, *An Effects Based Approach to Operations in the Domestic and Continental Operating Environment: A Case for Pragmatism* (Ottawa: DRDC CORA Technical Memorandum 2008-033, 2009).
Methods	50 % Lecture 0 % Class Exercises _50% Break Outs
Exercise(s)	
Break Outs	X Yes ___ No __#_5__ participants in each break out group
Discussion Questions	Does your organization have an embedded strategic analysis capability? In your view, does it require such a capability? In your experience, in what instances would your organization have benefitted from strategic analysis for decision-support? How should this capability be structured and how should it report to the senior level of your organization? If this capability did not report to the highest level of your organization, was its impact impaired? If so, how?

3.3 PRESENTATION

The second component – the case study presentation – has two main parts: a ten to twenty minute summary for a general officer, flag officer, or executive decision-makers and a second part for more junior staff officers or analysts wishing more detail. The specific power point template for presentation generation allows for modification by future lecturers.

After the title slide, there is a summary slide to capture an executive's attention and show immediate relevance, it includes information on the situation, decision to be made, objective, operational analysis' contribution, and the result or outcome. Figure 3-1 shows the summary slide.

Five to ten slides follow this summary slide expanding these areas. Figure 3-2 illustrates how the relevant parts can be explicated.

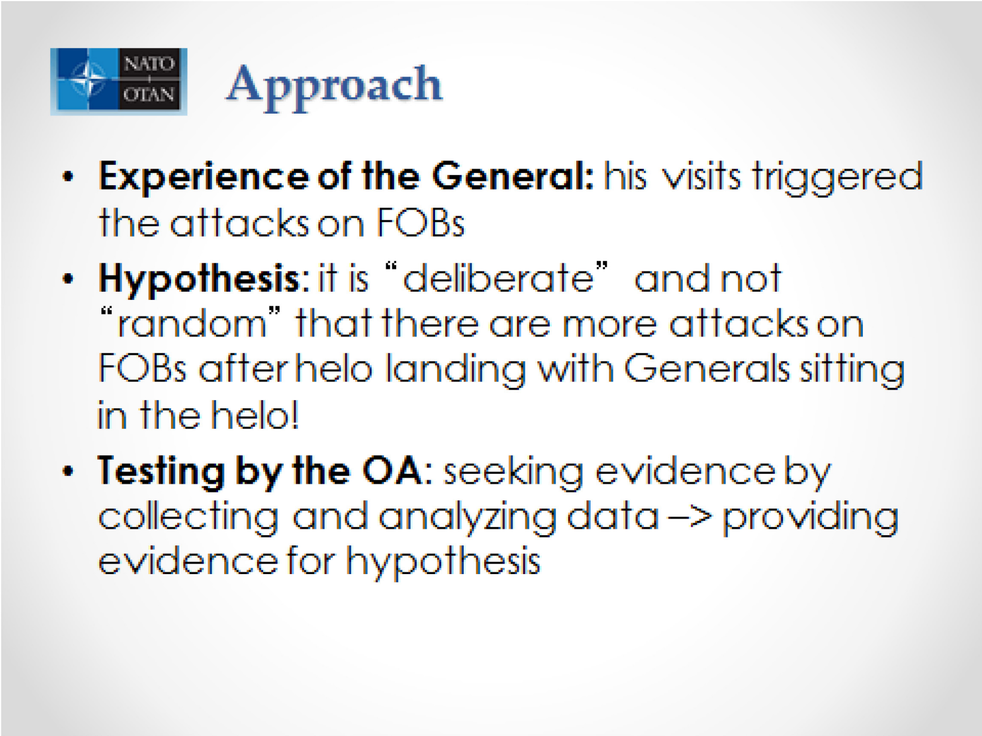


Figure 3-2: Adding Specifics to the Case Study.

A clear break occurs where even more detailed information is provided for staff officers and analysts. Figure 3-3 gives an example of detailed information on the conducted analysis.

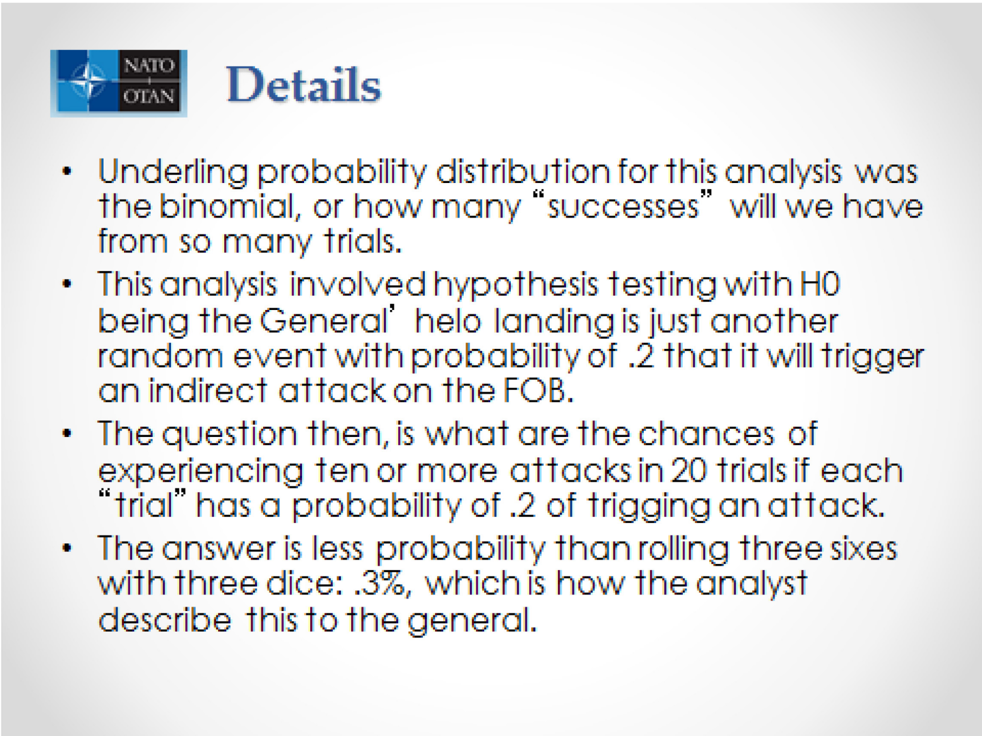


Figure 3-3: Detailed Information for Staff Officers and Analysts.

Additionally, every presentation is – where necessary and appropriate – annotated with additional information for the lecturer. This enables future presenters to conduct lectures regardless of their prior knowledge on a specific case study.

3.4 BACKGROUND READING MATERIAL

The third component – the background reading material – consists of any reading material deemed suited to facilitate the understanding of a topic (e.g. required pre-readings). There is no standard format for the presentation of this material.

All three components combined constitute an instructional module. Chapter 4 discusses the archiving of these modules as well as alternative delivery venues.

Chapter 4 – DELIVERY AND ARCHIVING RECOMMENDATIONS

Professor of Practice, Jeff Kline, Captain, USN (ret)
Naval Postgraduate School
1411 Cunningham Road, Room 236
Monterey, CA 93943
UNITED STATES

4.1 INTRODUCTION

This study's focus was to select topic areas, create instructional templates, and develop relevant case study instructional modules for senior officers to appreciate how operational analysis can assist in their decision-making challenges. Once developed, however, an accessible archiving medium, a venue for case study delivery, and a method for updating or creating new case studies past this particular study's effort are needed for NATO-wide use. This section presents several alternatives for consideration and discusses specific actions already taken to share this study's production.

4.2 ARCHIVING CASE STUDIES ON THE WEB

To make the case studies developed for this study accessible to all NATO staff and instructors a web-based approach is recommended. The case study presentations, their instructional modules, and any recommend readings can be stored electronically and assessable to all NATO Member Nations for review, download, and use. As such, the case studies may find their way into national and NATO Education and Training curricula. For NATO this means that the case studies need to be incorporated into the NATO Education and Training Opportunity Catalogue (ETOC) and thus advertise and make the material available to NATO and non-NATO Nations alike. A second step would be to incorporate the case studies into formal national and NATO courses. For NATO this would mean that the case studies would be accredited formally and thus can be offered as material in NATO courses or form their own course. For now SAS-098 participants leveraged Allied Command Transformation's operational analysis web site to initially display the study's finished products. This site may be found at https://transnet.act.nato.int/WISE/NATOAnalys and is displayed in Figure 4-1.

Figure 4-1: Allied Command Transformation (ACT) NATO Analysis Web Site.

It is envisioned that an instructor from a Member Nation's senior military schools or from a NATO school will review the various case studies to find one relevant to the senior officer that will receive the instruction, download the instructional material, modify it to the specific audience, and use it in presentation. As the analytical community experiences new situations where analysis is effectively used in operational decisions, new case studies are developed by NATO analysts using the standard templates and submitted to the ACT website to share with others. Again, however, in the future this role may also be filled by a NATO School, or a Member Nation's military school website. For example, a short summary of the OA executive case study program may be provided in the NATO's Education and Training Opportunity Catalogue (ETOC).

4.3 ALTERNATIVE VENUES FOR CASE STUDY DELIVERY

Several venues are recommended for case study delivery. These include STO lecture series, existing Member Nation and NATO courses and seminars, NATO exercises or war games, and during normal staff operations.

STO Lecture Series provide an opportunity to present case studies to NATO senior officers and NATO staff members as part of an existing NATO Lecture Series program. The STO SAS Panel is considering a Technical Activity Proposal (TAP) for a STO Lecture Series to present several case studies from this study to Allied Command Transformation, SHAPE, and the NATO Defence College. If executed, the Lecture Series will serve two purposes. The first is to deliver particular case studies of interest and operationalize this study, and the second is to inform NATO analysts of the existence of the case studies for their use.

Existing formal courses and seminars for senior officers in NATO and Member Nation defence schools may utilize these case studies for examples in normal course work. The publication of the SAS-098 study will aid in informing the NATO community's instructors of the case studies' availability, but annual NATO analytical and staff conferences provide other method to disseminate information on their existence. In addition, instructors will be invited to submit their own case studies modified in the standard format discussed in Chapter 3.

Flag and general officer seminars inside NATO exercises and war games provide another opportunity for case study presentation, particularly if the case study relates to that particular exercise's or game's objective. Exercise designers will use the case study matrix in Table 2-2 to select applicable case studies then schedule presentation time to the senior officers. If the case study's particular operational analytical tool is made available to assist in the exercise it will be reinforcing for the case study and provide increased appreciation for the analytical staff.

NATO staffs analysts may also use a particular case study to demonstrate a tool or analytical method which they wish to apply to a similar decision or upcoming operation. This meets the original intent of this study's charter by advancing the general officer's knowledge on analytical capabilities while inspiring the use of analysis in an operation. NATO staff analysts are also welcome to submit new case studies as they apply their craft to aid in decision-making and operations.

Appendix 1 – FULL CONTRIBUTOR LIST

Included below are the names of all those who contributed to this study, regardless of official membership status.

Name	Country
Aplak, Hakan Soner	Turkey
Bourdon, Sean	Canada
Buch, Heinrich	Germany
Cameron, Fred	Canada
Dell, Robert (Co-Chair)	USA
De Nijs, Johannes (Co-Chair)	NATO ACT
Dompke, Uwe	Germany
Dickson, Paul	Canada
Gladman, Brad	Canada
Grainger, Julius	NATO NCIA
Kline, Jeffrey (Co-Chair)	USA
Kose, Erkan	Turkey
Leopold, Armin	Germany
McNaught, Ken	United Kingdom
Monsuur, Herman	Netherlands
Pietzschmann, Harold	Germany
Robbe, Ephraim	Germany
Sok, Sam	USA
Treharne, James	USA
Utterbeeck, Filip Van	Belgium

Name	Country
Wellbrink, Joerg	Germany
Wetschoreck, Hans-Hermann	Germany
Wittmann, Christian	Germany
Zuna, Pavel	Czech Republic
Administrative and Staff Support	
Carroll, Chris (RTO CSO)	USA
Englehorn, Lyla (NPS)	USA
Landovsky, Roman	Czech Republic
Tahar, Rina	France

Appendix 2 – TERMS OF REFERENCE (TOR)

UNCLASSIFIED / UNLIMITED

Terms Of Reference (TOR)

SAS-098, RTG-043
on
Operations Research/Operations Analysis Orientation Course Curriculum for NATO Nations

I. Origin

A. Background

As a professional group, the military personnel of NATO nations receive high-level, quality education from a wide range of academic disciplines throughout their career. The need for high-quality analysis to support decision making in military acquisition, in force development, in force employment and in management of the national military and NATO organizations compelling that continued emphasis be placed on scientific rigor and academic qualities. While in the academic world, the research and development organizations, and the science labs, these attitudes are reinforced daily, the work environment of the military staffs is focused more on the results, achievements and the bottom-line, and therefore can lead the military away from scientific methods.

Military Operations Research (OR) or Operational Analysis (OA) is defined as the application of scientific methods to assist executive decision makers and as such is the analytical study of military problems undertaken to provide responsible commanders and staff agencies with scientific based reasoning for decisions on actions to improve military operations. OR/OA provides support for decisions in most of the military management domains, and OR/OA presents itself as a powerful tool to help improve the quality of decision making by illuminating key issues, assumptions and sources of information. OR/OA is an academic discipline whose roots are in application of hard and soft science methods in military decision making during World War II. Many NATO nations have a rich history of OR/OA and currently employ it extensively throughout their organizations. These nations also have many OR/OA educational opportunities for their military personnel. However, such opportunities are not universal. Sharing experiences and developing educational opportunities for NATO decision makers and their staff will enhance OR/OA use throughout NATO.

B. Justification (Relevance for NATO)

The need to use OR/OA in staff and commanders decision making is easily overlooked in todays busy schedules, however, OR/OA when applied successfully, will almost always result in savings and increased efficiency or effectiveness or both. Appreciation of the contribution of OR/OA by NATOs military may therefore be necessary.

II. Objectives

The objective of this effort is the design of a set of instructional modules to demonstrate to the non-analyst the value provided by various analytical tools in operational decision making. The material will serve as source material for integration into the continuing education curriculums of NATO and national military staffs. For example, these modules may be used to build a tailored week-long course for senior officers (up to OF-5) or in condensed form serve as an abbreviated information session for flag and general officers. Nations will use the modules to tailor their own courses. NATO nations with little or no OR/OA heritage will be provided with material they can use to raise the awareness among their military professionals.

This proposal attempts to gather national OR/OA experts, preferably with teaching experiences in military OR/OA, to propose the OR/OA curriculum modules for such a course and design it so that it can be used and offered in national and NATO military academies, schools and colleges. It may be necessary to survey national defence education institutes to understand the level of OR/OA teaching and determine for which topics and to which depth level these lessons need to be developed. The group will develop learning objectives, module outlines, framework lessons plans and applicable class material for each module. The group will gather and build from existing material from national OR/OA courses and build the modules for use in NATO courses or in national curriculums. This course material could be further tailored by the nations to serve national purposes.

UNCLASSIFIED / UNLIMITED

Terms Of Reference (TOR)

III. Resources

A. Membership

Members of the Task Group should have a strong background in OA/OR, with a background in OA/OR education desired. Belgium, Canada, Czech Republic, Germany, Netherlands, United Kingdom, and the United States have expressed a willingness to participate in the work.

CAPT (USN, retired) Jeff Kline of the United States is willing to lead the Task Group.

Co-Chair : Mr. Johannes DE NIJS Netherlands
Co-Chair : Dr. Robert DELL United States
Co-Chair : Capt USN (ret) Jeffrey E. KLINE United States

Lead Nation: United States

Nations and Bodies Really Participating: ACT, Czech Republic, Germany, Netherlands, United States

B. National And/Or NATO Resources Needed :

It is expected that the RTG will meet at least twice a year over its duration. Nations should be prepared to dedicate funds necessary to support the required travel of the RTG members. However, if formed, this RTG will explore the maximum use of VTC and web technologies for coordination and work to limit travel requirements. In addition, nations should allocate sufficient time within their respective research work programs to allow assigned researchers to perform the necessary activities of the RTG.

C. RTA resources needed

RTA meeting facilities will be used for the initial meeting of the RTG.

IV. Security Classification Level

The security level will be Unclassified/Unlimited

V. Participation By Partner Nations

Invitation to participate will be extended to all NATO nations, as well as NATO Partner nations.

see Membership

VI. Liaison

The Task Group will seek cooperation with those organizations whose activities are connected to this topic.

Operations Research / Operations Analysis Orientation Course Curriculum for NATO Nations

ANNEX

Application Areas with Supporting Curriculum

This annex document is intended to accompany the full report.

VOLUME 1

A.0 ORIENTATION

The developed curriculum is separated out into seven pre-defined ***Application Areas:***

1) Support for Military Operations;
2) Strategic Planning;
3) Transformation;
4) Logistics and Acquisition;
5) Scheduling;
6) Other; and
7) Overview.

Within each of these Application Areas, the case studies fall into several distinct ***Operational Analysis Discipline Areas***. Some case studies fall in two of these discipline areas. These include:

a) Analytics and Assessment;
b) Probability Statistics Data Analysis;
c) Optimization;
d) Decision Analysis and Game Theory;
e) Soft OA;
f) Simulation; and
g) Data Visualization.

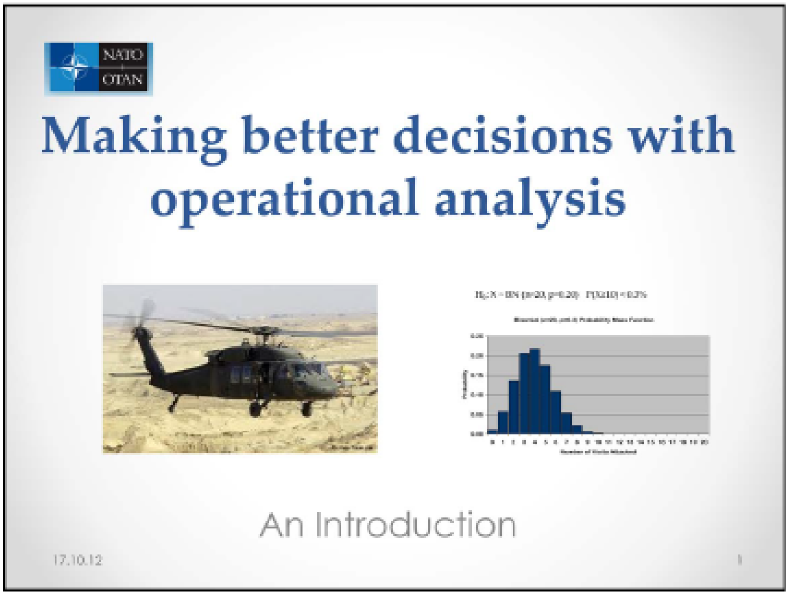
For each developed case study, this annex includes the module overview followed by the slides and instructor notes for each case study organized within the pre-defined Application Areas. Note that some case studies are included in more than one Application Area.

A.1 OVERVIEW

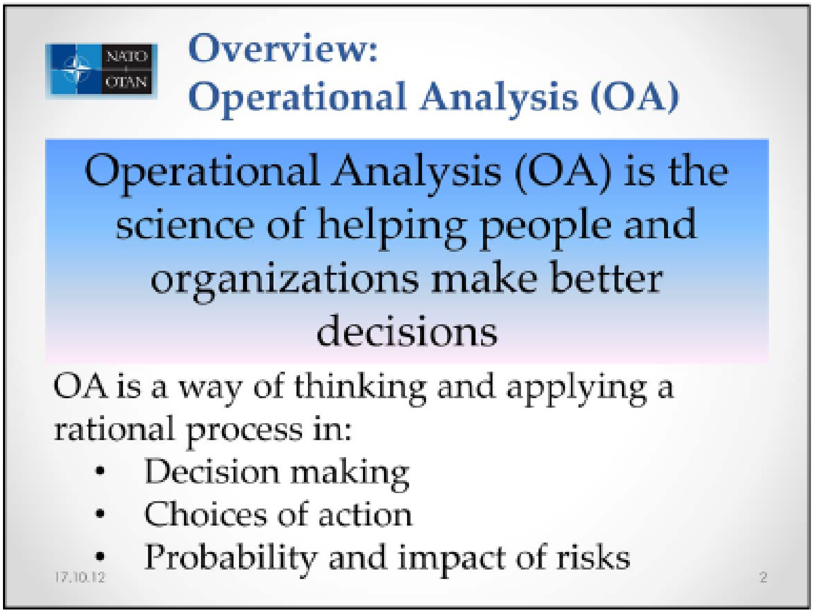
A.1.1 Making Better Decisions with Operational Analysis

INSTRUCTIONAL MODULE SUMMARY

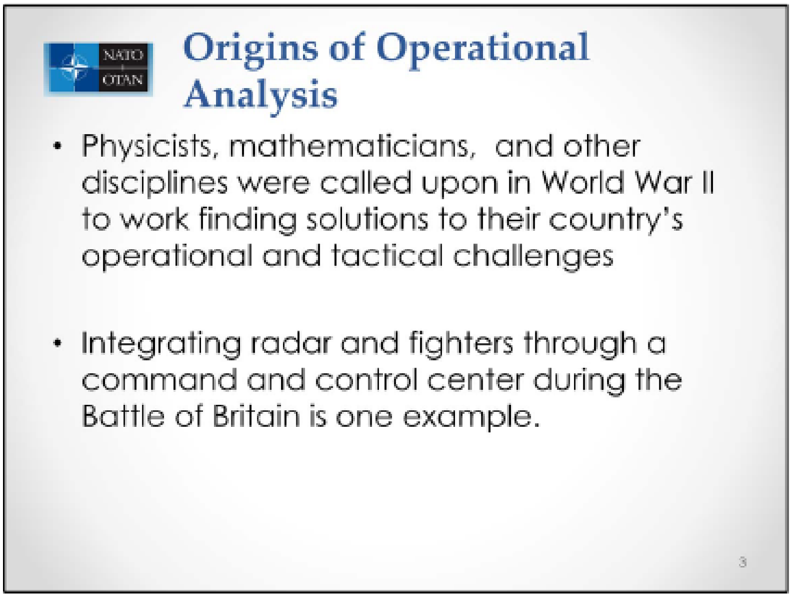
Title	Making Better Decisions with Operational Analysis
Faculty Name(s)	Jeff Kline, Naval Postgraduate School, Monterey, California, USA
Length	15 – 30 minutes
Learning Objectives	Provide an appreciation for how operational analysis can aid in decision-making. Provide a general definition of operational analysis, its purpose, and history. Give some example tools used by analyst to aid in decisions.
Outcomes	As the result of this module, participants will be able to: Better utilize the analysts on a NATO staff to aid in operations and decisions in planning.
Content Outline	Operational Analysis defined. Origins of Operational Analysis. Contributions of OA to decisions. Examples of OA approaches and tools. Case study matrix for how it has been used.
Materials	List Required Pre-Readings: None.
Methods	100% Lecture 0% Class Exercises. ____% Break Outs.
Exercise(s)	Seminar participants will be ask to discuss relevancy of approaches to their past decision challenges.
Break Outs	___ Yes X No. __#___ participants in each break out group.
Discussion Questions	What are your experiences with manual scheduling? How might optimization improve that process?



This presentation is an overview of operational analysis and some of its tools to aid in flag and general officer decision making. It is not meant to be a comprehensive inventory of the art and tools associated with operations research, operational analysis, and analytics. Nor are the definitions of methods academically rigorous. It's purpose is to give a brief summary on how an operations analyst can aid a senior decision maker in making better decisions in language a senior decision maker may understand.

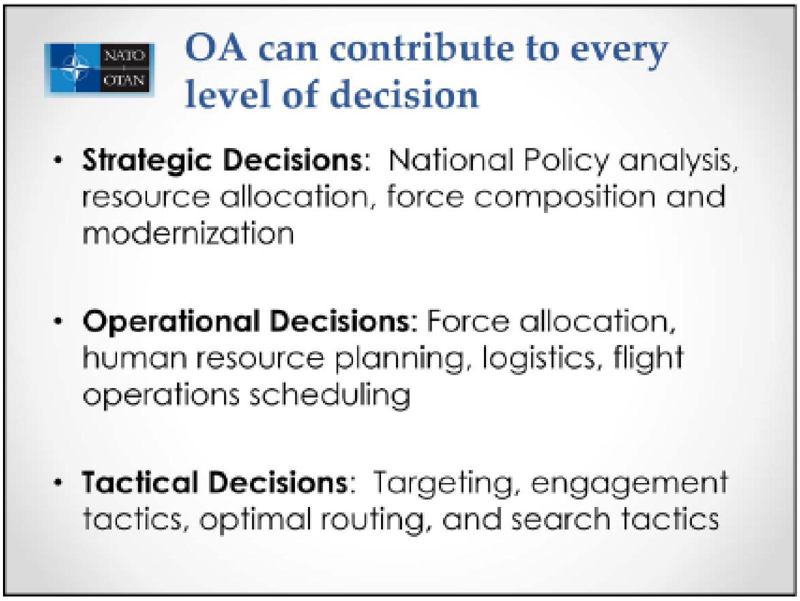


More formally, operational analysis is the development and application of mathematical models, statistical analyses, simulations, analytical reasoning, analytics and common sense to the understanding and improvement of real-world operations. Just as important, it is a way of thinking and applying a technical and rational process to understand problems, choices, outcomes, and risk.

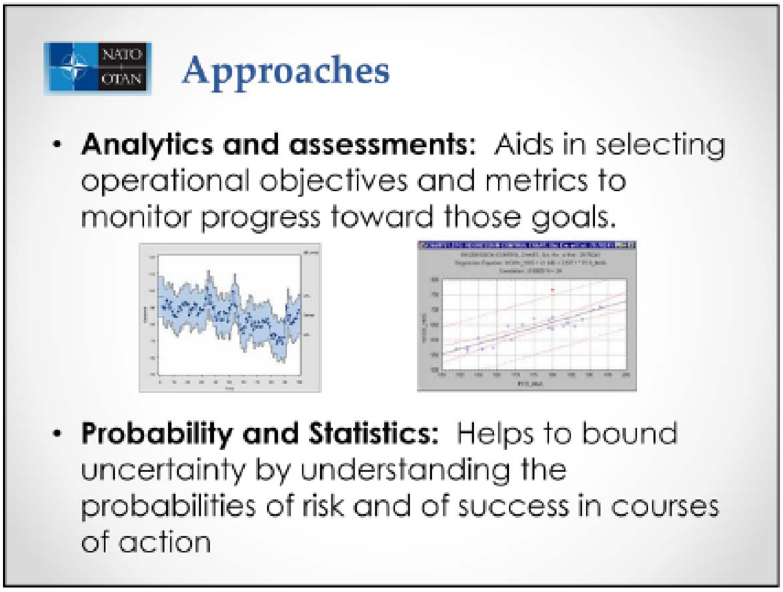


OR marks its origins as a discipline from the combined efforts of scientists to help tackle their countries' operational and tactic issues during World War II.

The British applied OR to help design an integrated air defense system during the Battle of Britain, while both the Americans and Germans applied these techniques in the Battle of the Atlantic.

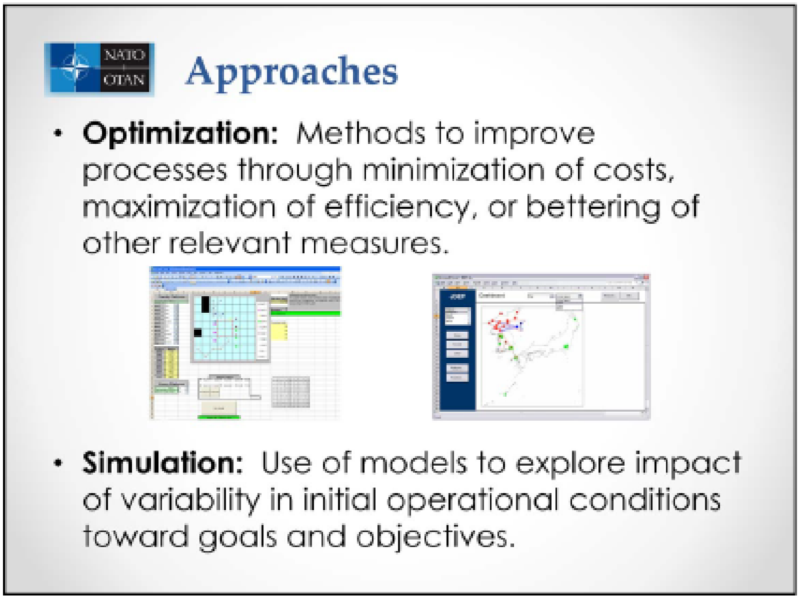


Today, Operations Research and operational analysis has been applied at every level of decision making, from international policy creation to routing of search assets for downed submarines.



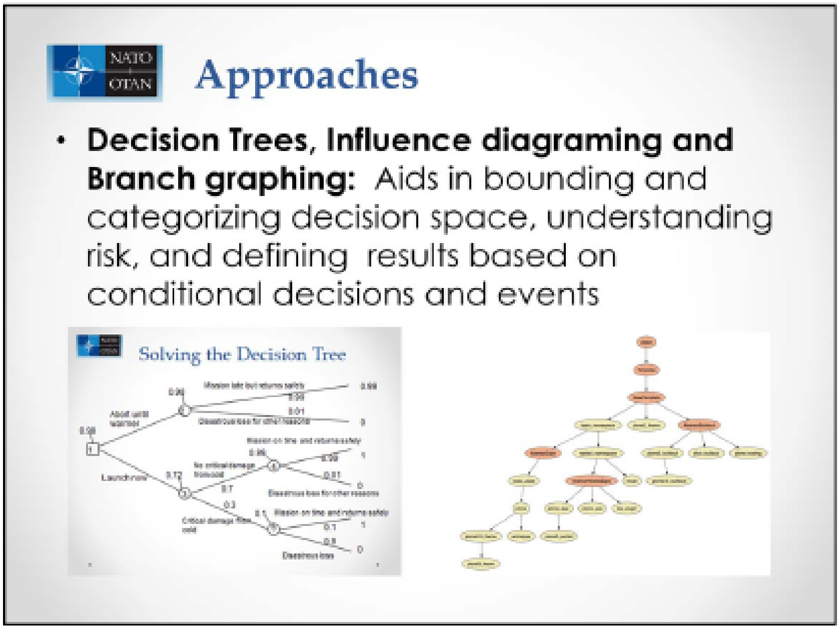
Analytics and assessments can be directly integrated into a commander's planning process to help identify measurable objectives from overall operational goals and select metrics to monitor progress toward those goals. Many staffs now have net assesssment sections. Integrating operational analysts with these sections and planning efforts will increase rigor in the quantitative monitor of mission achievement and improved situational awareness.

Probability and statistics represent a host of tools to help bound uncertainity and quantify risk in decision making. These techniques are used in cost estimation, risk assessment, search tactics, process modeling, hypthosis testing, regression modeling, survey and data analysis. These techniques have been used in such diverse areas as to confirm a general officer's helo was being targeted to understanding how much is required for a contested rescue mission.

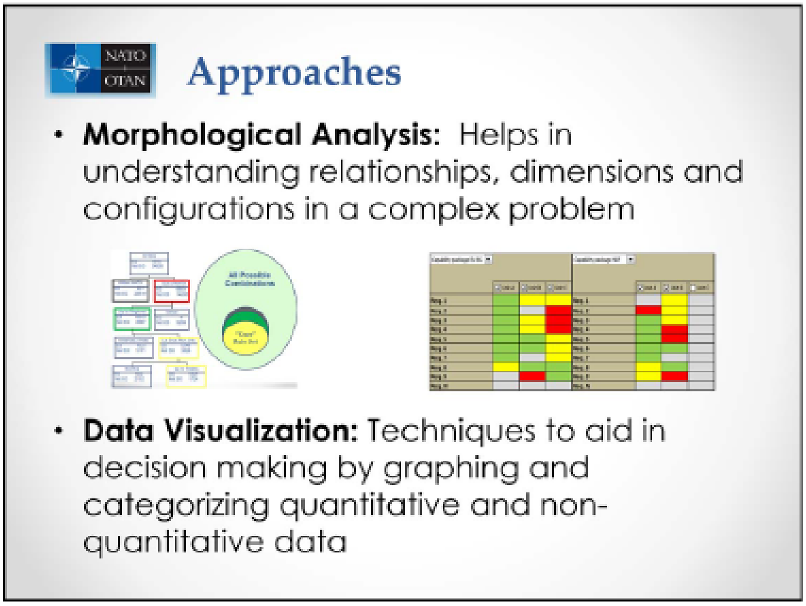


Optimization is a form of modeling that provides best solutions dependent on objectives and contraints. It is used in such areas as schedule aircraft lift to stationing ballistic missile defense sites.

Simulation can be used to explore and identify the important initial conditions of a conflict (i.e. Sensor location and performance, weather, weapon location and performance) to understand risk assocated with various courses of action. It has been used in everything for force structure planning to tactical evaluation.

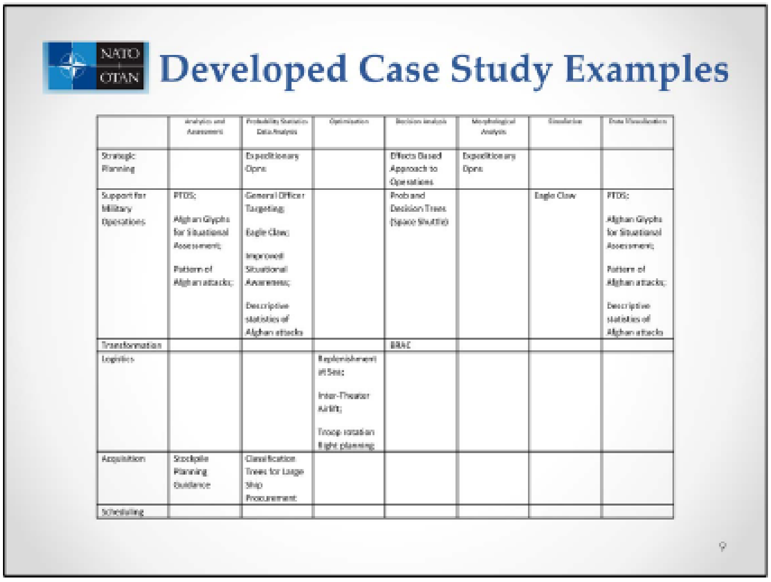


Decision trees, influence diagraming and branch graphicing are used to understand the problem, catagorize and deconstruct a complex issue, and determine probabilistic risk. These techniques have been used in analyzing accidents like the space shuttle events to determining courses of action in operations.



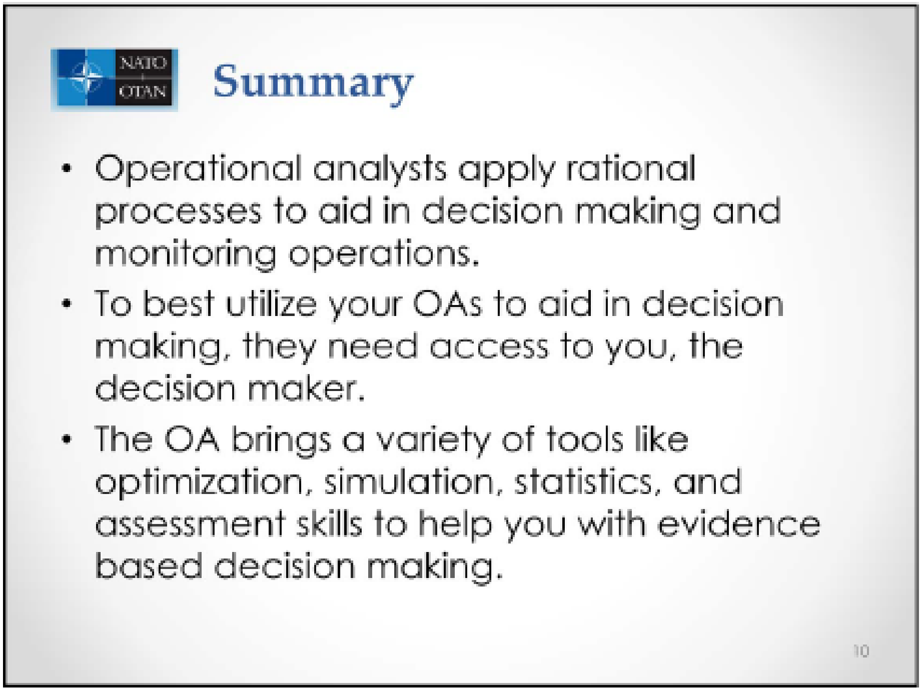
Morphological analysis can help in deconstructing qualitative complex issues to help in understanding dimensions to the problem. An example is creating a precise defination for expeditionary operations for NATO based on mission requirements and description.

Data visualization aids decision makers and planners on understanding relationships and assessments of quantitative and qualitative issues. A recent example is of its use is to assess military commands' abilities to carry out specific NATO tasking.



	Analytics and Assessment	Probability Statistics Data Analysis	Optimization	Decision Analysis	Morphological Analysis	Simulation	Data Visualization
Strategic Planning		Expeditionary Opns		Effects Based Approach to Operations	Expeditionary Opns		
Support for Military Operations	PTDS; Afghan Glyphs for Situational Assessment; Pattern of Afghan attacks;	General Officer Targeting; Eagle Claw; Improved Situational Awareness; Descriptive statistics of Afghan attacks		Prob and Decision Trees (Space Shuttle)		Eagle Claw	PTDS; Afghan Glyphs for Situational Assessment; Pattern of Afghan attacks; Descriptive statistics of Afghan attacks
Transformation				BRAC			
Logistics			Replenishment at Sea; Inter-Theater Airlift; Troop rotation flight planning				
Acquisition	Stockpile Planning Guidance	Classification Trees for Large Ship Procurement					
Scheduling							

Brief case study presentations have been created to demonstrate specific use of these tools in real world examples where flag or general officer decisions were involved. This matrix is an illustrative set of these case studies.


NATO
OTAN
Summary
• Operational analysts apply rational processes to aid in decision making and monitoring operations.
• To best utilize your OAs to aid in decision making, they need access to you, the decision maker.
• The OA brings a variety of tools like optimization, simulation, statistics, and assessment skills to help you with evidence based decision making.
10

A.1.2 Case Study Collection Overview

	Analytics and Assessment	Probability Statistics Data Analysis	Optimization	Decision Analysis and Game Theory	Soft OA	Simulation	Data Visualization
Strategic Planning (J5)	Strategic Analysis and EBAO			Peace Support Operation Planning			
Support for Military Operations (J3/J5)	Improved Situational Awareness (Correlation and Pattern) Improved Situational Awareness (Descriptive Statistics)	General Officer Targeting; Persistent Threat Detection System Improved Situational Awareness (Correlation and Pattern) Improved Situational Awareness (Descriptive Statistics)	Intra-theater Air Lift	Peace Support Operation Planning	Chernoff Faces		Persistent Threat Detection System Chernoff Faces
Transformation (J4/J5)	Visual Analytics in Operational Capability Requirements Evaluation			Base Realignment and Closure			

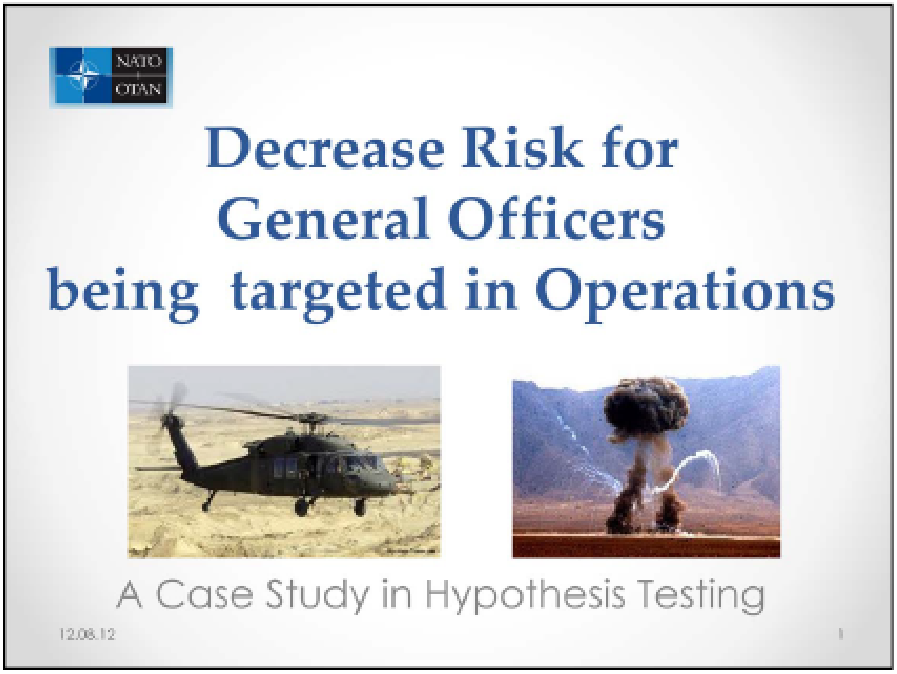
	Analytics and Assessment	Probability Statistics Data Analysis	Optimization	Decision Analysis and Game Theory	Soft OA	Simulation	Data Visualization
Logistics and Acquisition (J4/J8/J9)		Cost Estimation for Major Defence Systems (LPD ship)	Replenishment at Sea DEU Out Planning Intra-theater Lift Stockpile Planning Guidance	Cost Estimation for Major Defence Systems (LPD ship)			
Scheduling (J3)			Replenishment at Sea DEU Out Planning				
Other	Operation Eagle Claw	Operation Eagle Claw Probability and Decision Trees: Challenger Space Shuttle		Probability and Decision Trees: Challenger Space Shuttle	Expeditionary Operations (Morphological Analysis)	Operation Eagle Claw	
Overview	Making Better Decisions with operational Analysis: An Overview	Making Better Decisions with Operational Analysis: An overview	Making Better Decisions with Operational Analysis: An overview	Making Better Decisions with Operational Analysis: An overview	Making Better Decisions with Operational Analysis: An overview	Making Better Decisions with Operational Analysis: An overview	Making Better Decisions with Operational Analysis: An overview

A.2 SUPPORT FOR MILITARY OPERATIONS

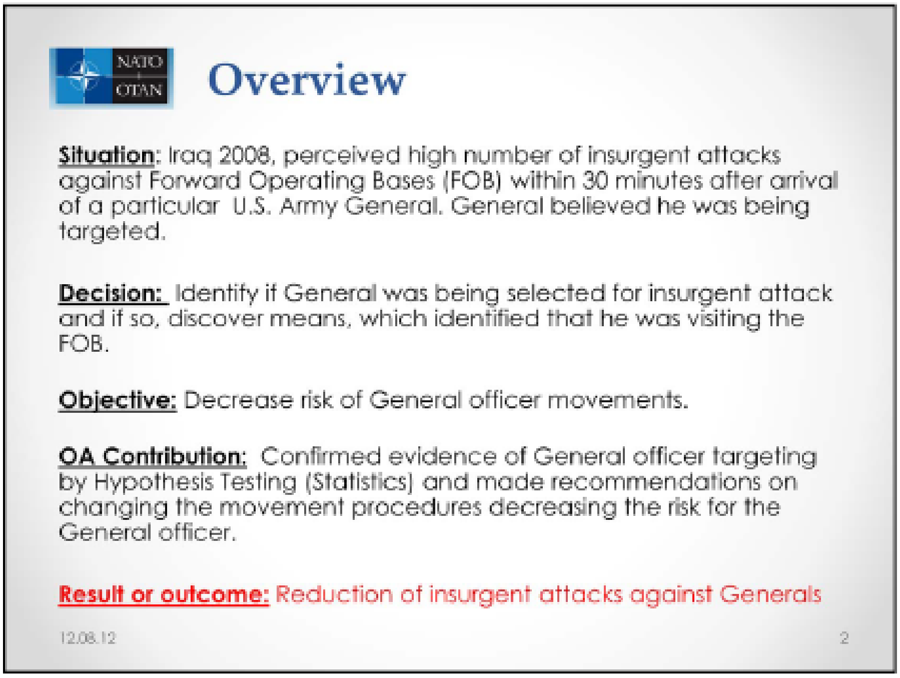
A.2.1 General Officer Targeting

INSTRUCTIONAL MODULE SUMMARY

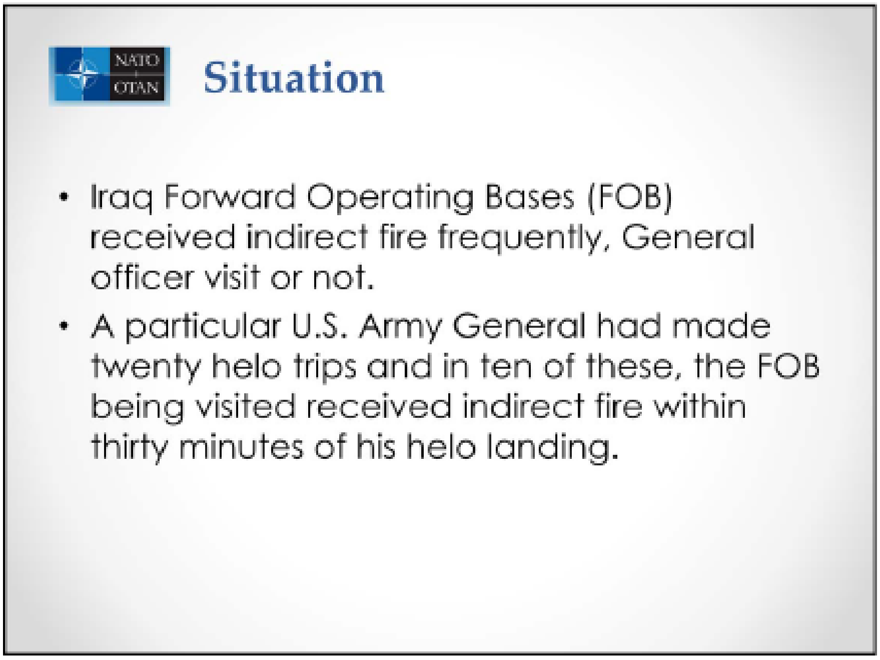
Title	Decrease Risk for General Officers Being Targeted in Operations: A Case Study in Hypothesis Testing
Faculty Name(s)	Bundeswehr Planning Office, Ottobrunn, DEU
Length	20 – 30 minutes
Learning Objectives	Understand that OA methods can be used to test critical assumptions underlying the decision-making process.
Outcomes	As the result of this module, participants will be able to: Recognize similar applications where an analysis by OA staff could support the decision-making process concerning critical security issues.
Content Outline	Case Study: Decrease Risk for General Officers Being Targeted in Operations.
Materials	None.
Methods	100% Lecture 0% Class Exercises. _____% Break Outs.
Exercise(s)	None.
Break Outs	___ Yes X No. __#___ participants in each break out group.
Discussion Questions	Did you have a similar case in the past? Can you think of a current case in your area of responsibility?



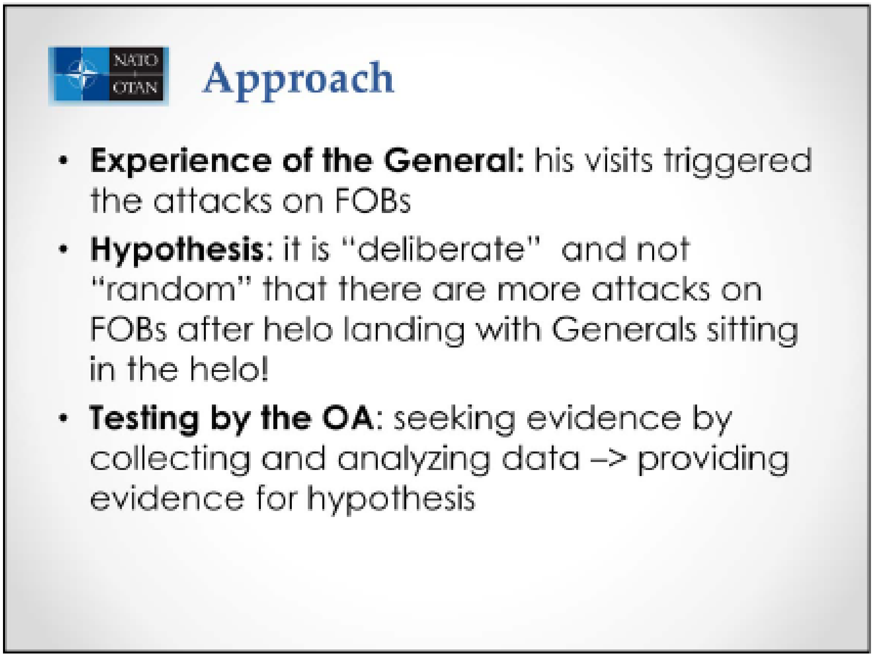
The case study addresses the concern of a general officer during Iraq operations. He felt forward operating bases were being attacked with more frequency when he was present. These attacks occurred while conducting routine visits via helicopter.



In this situation, the general turned to his analysts to understand if he was being targeted by insurgents. The analysts begin to look at the number of morter attacks occuring at all bases compared to attacks with the general was present.

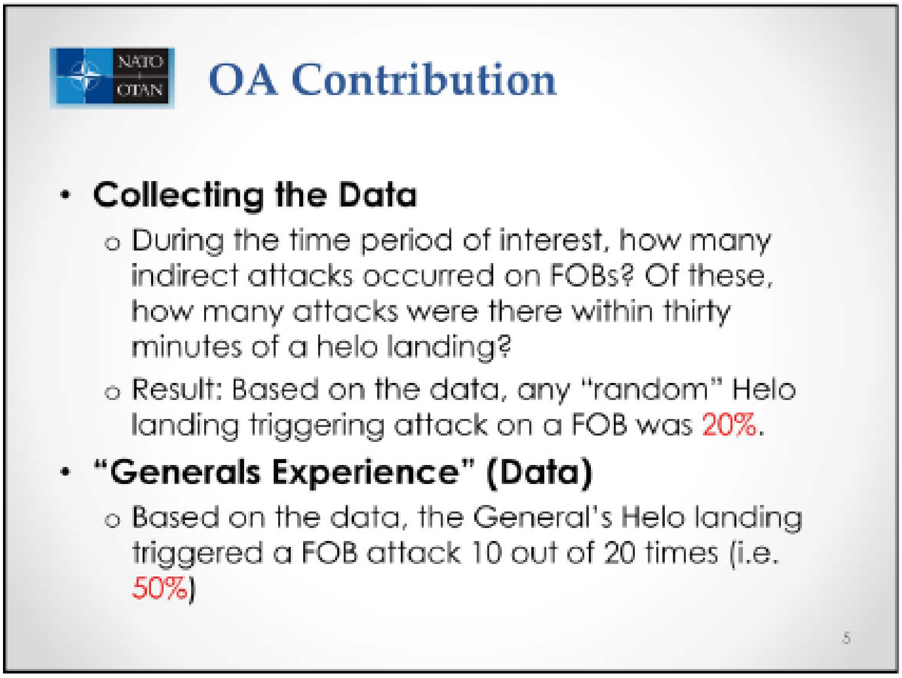


All forward operating bases received indirect fire, but in the general's case, in twenty visits to the bases, ten were attacked within 30 minutes of his landing.

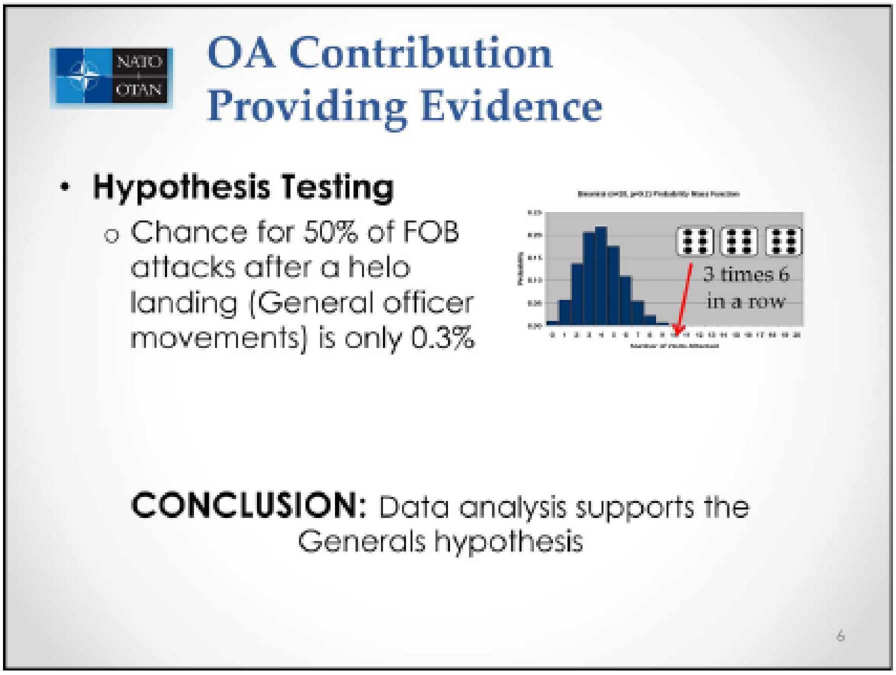


The general's personal experience led him to believe he was being targeted, but was this different than any normal attack schedule on any base regardless of his presence?

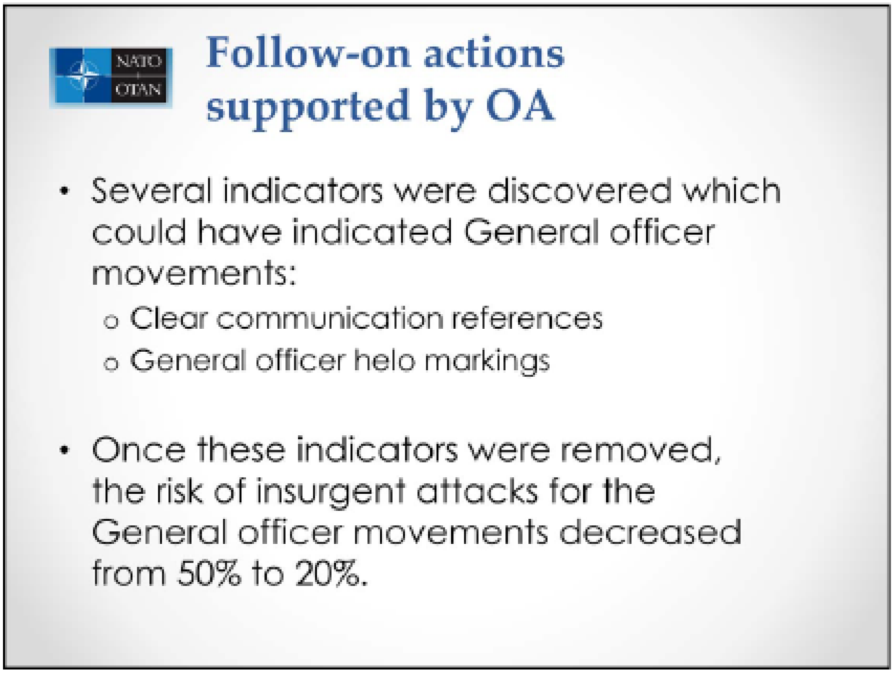
By collecting the data across all forward bases, the operational analysts were able to compare attacks that occurred in all cases with attacks occuring only when the general was present.



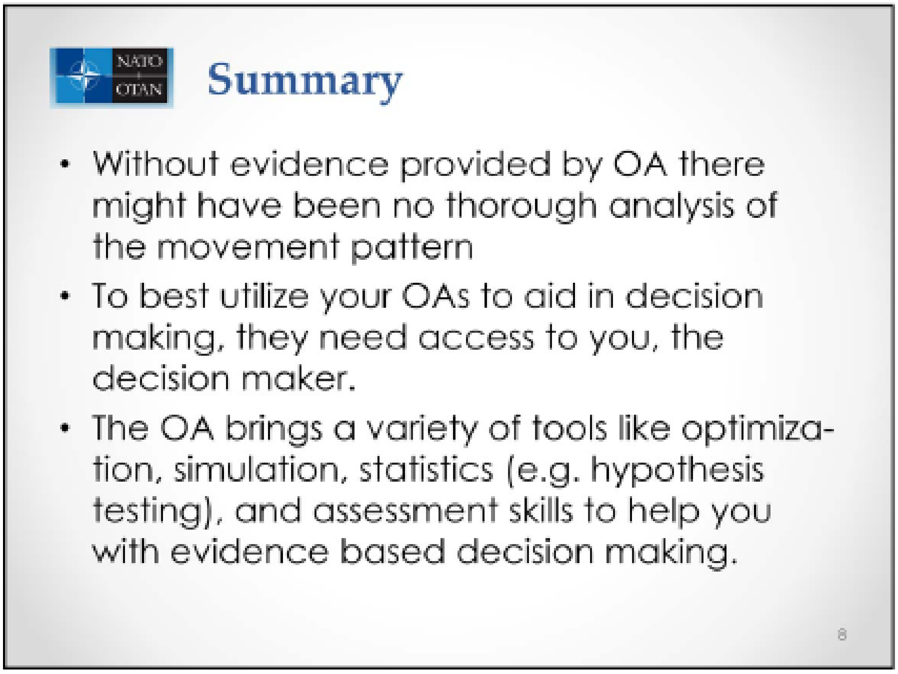
Using a helo landing as a trigger point, it was discovered that an attack followed a helo landing about 20% of the time in all bases. However, if was the general's helo, an attacked followed 50% of the time.



The following conclusion can then be made. If the general was NOT being targeted, the chances of him experiencing 10 out of 20 attacks just on random attacks is the same as rolling three sixes. Therefore, the data supports the General's impression that he is being targeted.



As a follow-on, it was discovered that the general's pilot used his same call sign to radio the general's arrival as they approached the forward operating base. These transmission were not secure. In addition, the general's helo had unique markings that once removed, led to decrease in the number of attacks experienced after his landings.



The contribution the operational analyst was to bring data analysis skills to determine if the general's concerns were valid. This is just one tool set an analyst can bring to the staff.

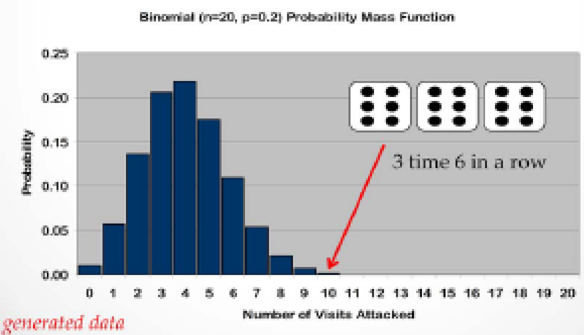
What is Hypothesis Testing?

- Field of applied statistics and probability that seeks to find relationships between metrics, data, and variables.
- Helpful to quantify risk or compare statistical data.
- In this case to find if there is evidence for targeting the General officer by using a standard probability distribution.

Hypothesis Testing

MNC-I requested assistance in evaluating the likelihood that insurgents were targeting a Coalition general officer during his visits to various FOBs.

H_0: X ~ BN (n=20, p=0.20) $P(X \geq 10) < 0.3\%$



Randomly generated data

GO had made 20 trips. He had received IDF on 10 of the 20. Random?

Met with the G3-Air and identified all flights in the last month in Baghdad. Determined how many FOBS received IDF w/in 30 minutes on landing = 20%.

How many independent flights out of 20 should be attacked if p=0.20?

How do you explain 0.3%?

Details

- Underling probability distribution for this analysis was the binomial, or how many "successes" will we have from so many trials.
- This analysis involved hypothesis testing with H0 being the General' helo landing is just another random event with probability of .2 that it will trigger an indirect attack on the FOB.
- The question then, is what are the chances of experiencing ten or more attacks in 20 trials if each "trial" has a probability of .2 of trigging an attack.
- The answer is less probability than rolling three sixes with three dice: .3%, which is how the analyst describe this to the general.

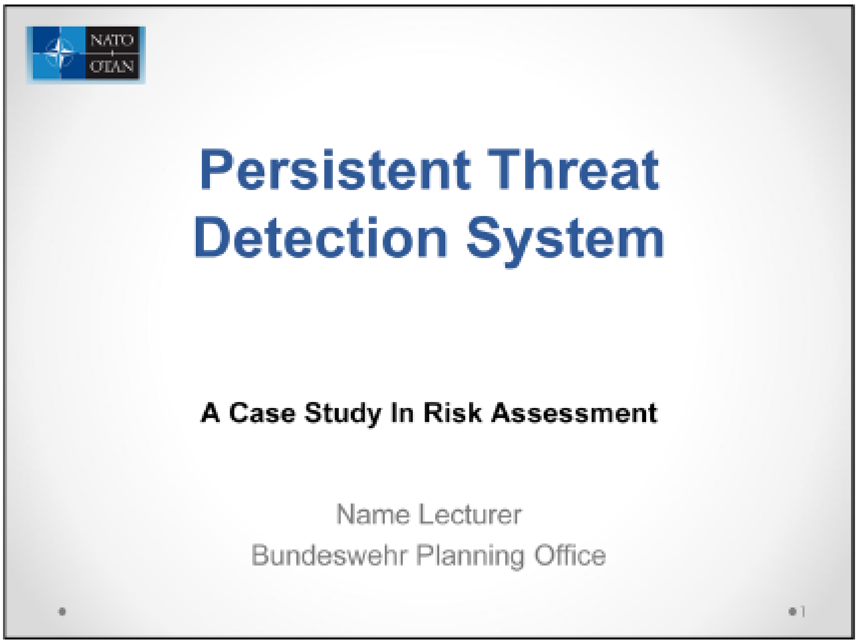
Strengths and Weaknesses of Hypothesis Testing

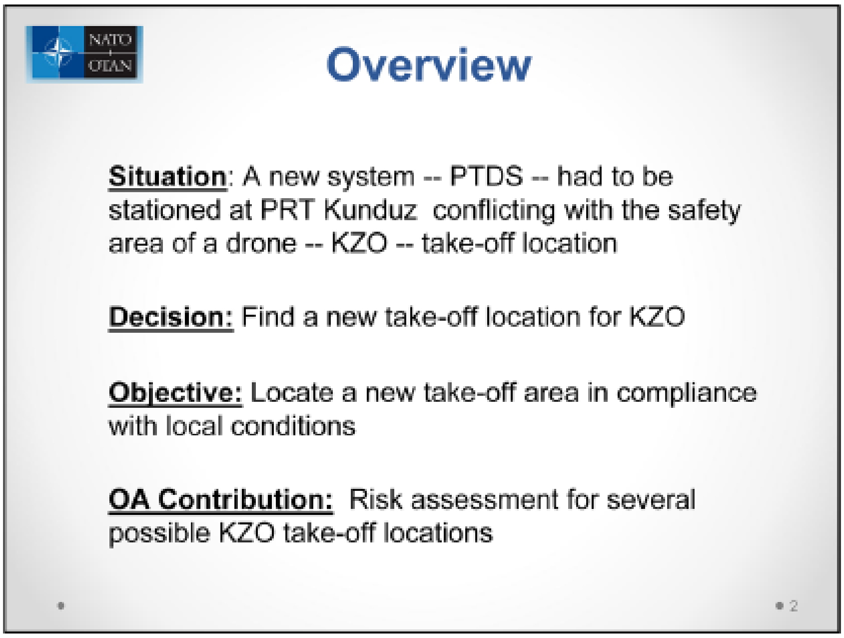
- Does not always discover "cause and effect", but can provide insight in relation (correlation).
- Requires a good data base on objects of interest
- In many cases, assumes environment in the immediate future will be the same as the immediate past for data consistency.

A.2.2 Persistent Threat Detection System

INSTRUCTIONAL MODULE SUMMARY

Title	Persistent Threat Detection System
Faculty Name(s)	Bundeswehr Planning Office, Ottobrunn, DEU
Length	20 – 30 minutes
Learning Objectives	Understand the advantage of a mathematical-based analysis.
Outcomes	As the result of this module, participants will be able to: Recognize similar applications where an analysis by OA staff could support planning.
Content Outline	Case Study: PTDS.
Materials	None.
Methods	100% Lecture 20% Class Exercises. _____% Break Outs.
Exercise(s)	None.
Break Outs	___ Yes X No. __#___ participants in each break out group.
Discussion Questions	Did you have a similar case in the past? Can you think of a current case in your area of responsibility?





Read points

Note:

PTDS - Persistent Threat Detection System - is a tethered aerostat-based system

KZO is the German abbreviation for “Kleinfluggerät für Zielortung”. KZO is a small UAV. The next slide will provide more details about the PTDS and KZO.

PTDS and KZO

PTDS is a tethered aerostat-based system equipped with multi-mission sensors to provide long endurance intelligence, surveillance, reconnaissance and communications in support of coalition forces.

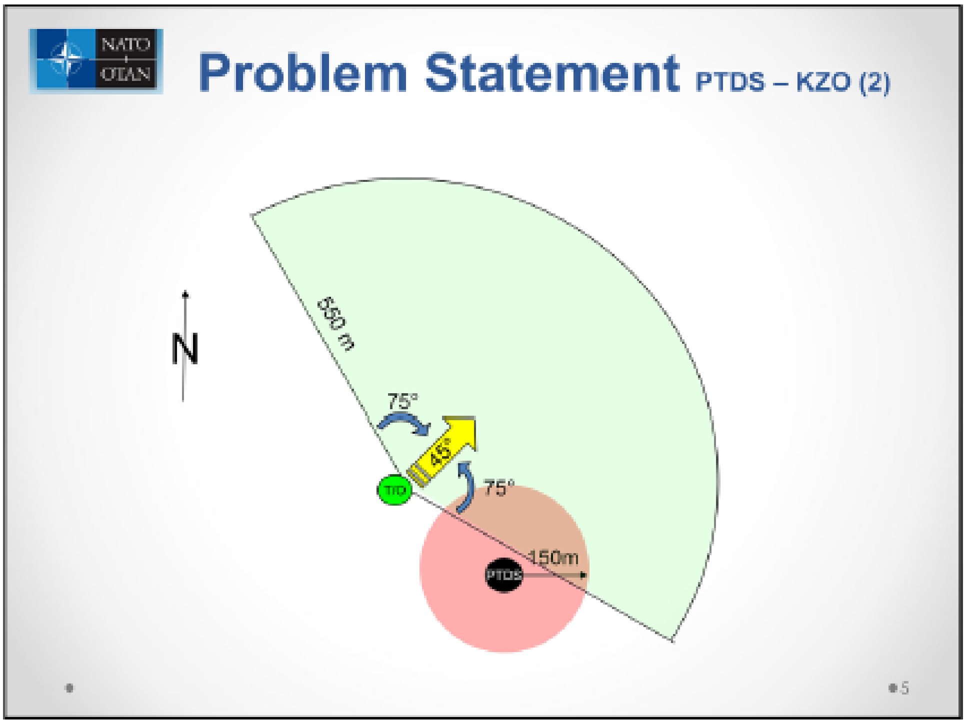
KZO is a highly advanced surveillance, reconnaissance and target localization system. The payload used for his specific task is an imaging infrared sensor capable of acquiring highly accurate data on stationary and moving targets at any time of the day or night.

3

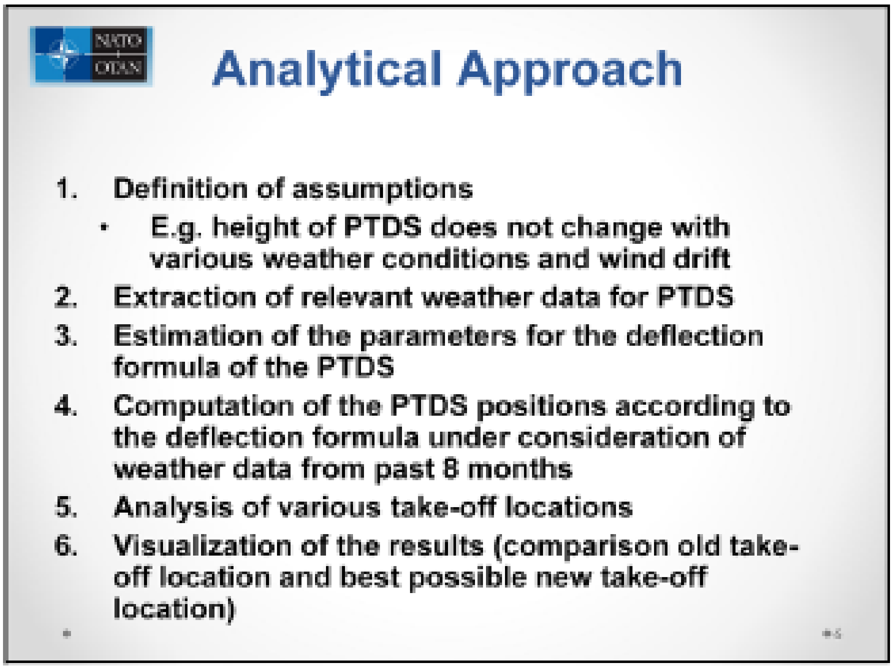
Problem Statement PTDS – KZO (1)

- PTDS was introduced in 2011 in the area of PRT Kunduz.
- The location for the mooring system for PTDS was given and is therefore a fixed parameter.
- The safety areas of the two systems (PTDS and KZO) were critically overlapping because the PTDS mooring system is near the take-off location of the KZO.
- A new take-off location for the KZO had to be determined with the goal to minimize the overlap between the safety areas.
- Based on local restrictions, specific take-off locations were analyzed with regard to the risk of overlapping safety areas.

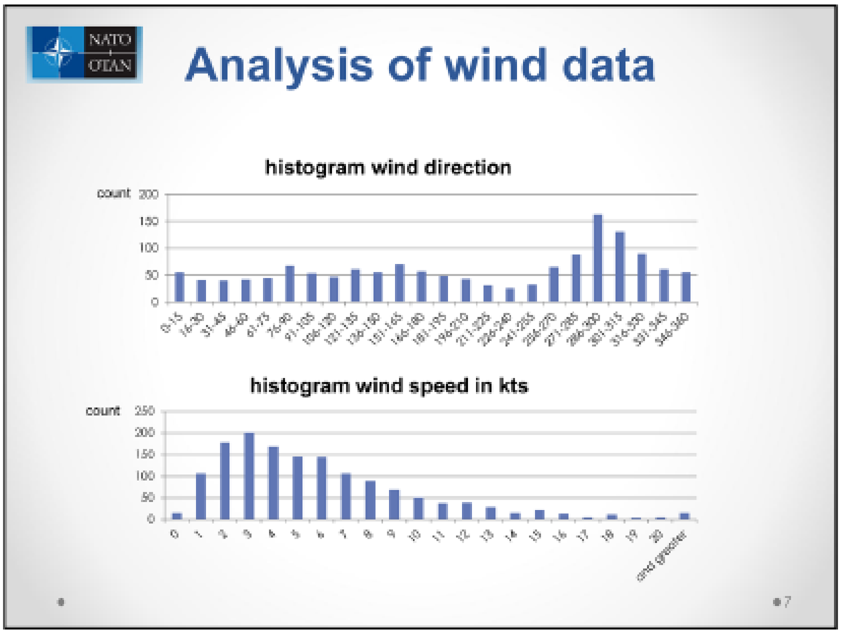
4



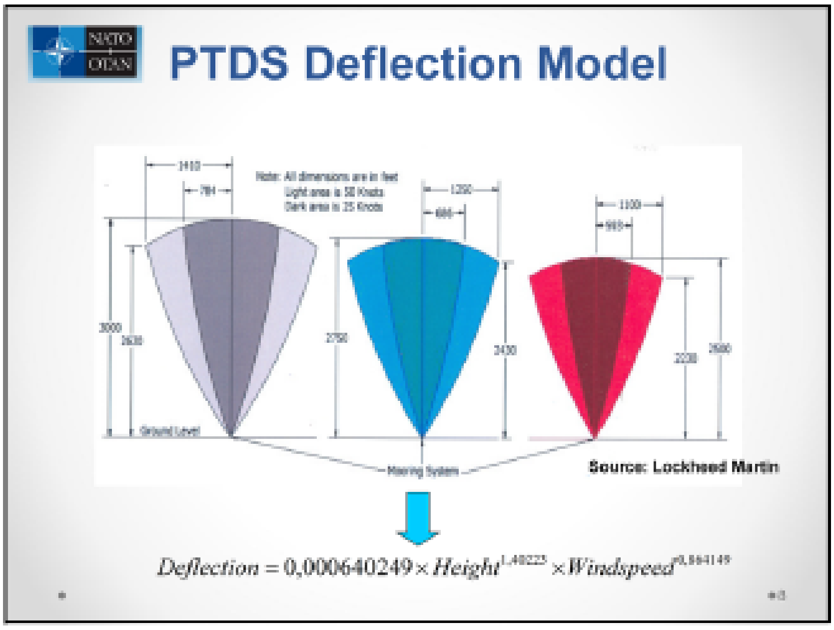
Here the safety areas of the both systems are visualized. The KZO, depicted as T/O, takes off in a north-easterly direction. It has a safety area with a range of 550 m. This safety area is fixed, because it is in relation to the take-off location and not the moving KZO. The PTDS has a safety area of 150 m around the airship. The PTDS and its corresponding safety area will drift depending on speed and direction of existing winds. The operational altitude of the PTDS is between 1000 and 1500 meters.



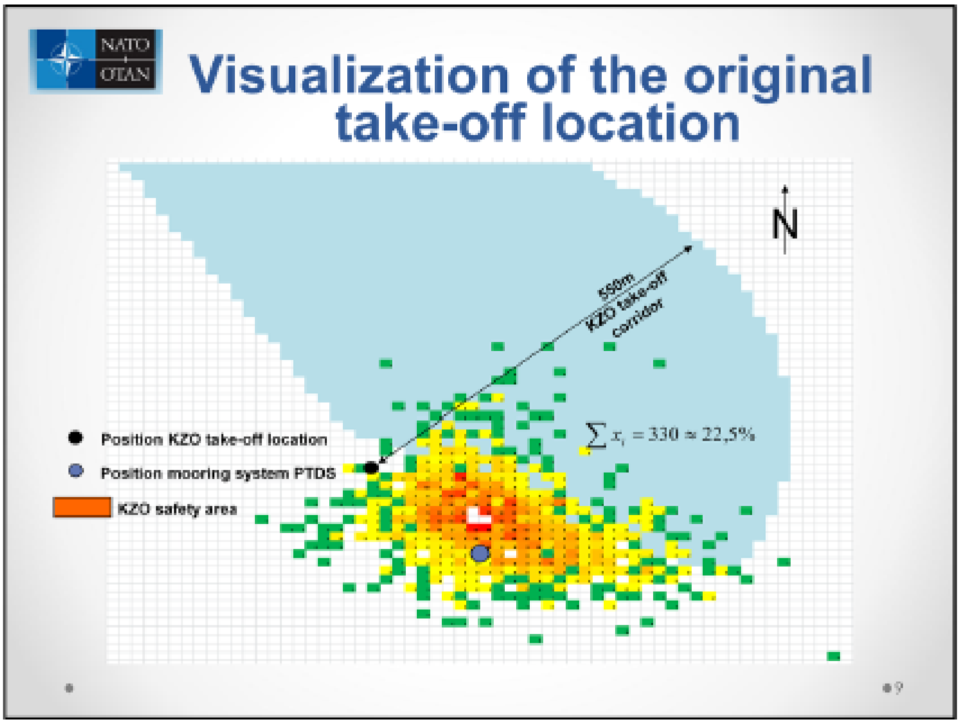
The analytical approach was as follows. First of all, assumptions had to be taken to simplify the real aerostat drifting problem. One assumption was that the PTDS will not lose height, if it drifts away from the mooring system. After defining the problem, weather data had to be obtained. German artillery units collect wind speed and wind direction daily at several heights and times of the day. The data for an altitude of 1000-1500 meters (operational height of the PTDS) were extracted from existing text-files via Java. 1466 dates were extracted covering 8 months of weather data around PRT Kunduz. Then the deflection of the PTDS as a function of height and wind speed had to be determined. With this formula the fictive position of the PTDS in the last 8 months could be calculated. Several possible take-off locations could be analyzed with regard to their risk of overlapping safety areas of the two systems. Finally, the results were visualized for easier understanding. On the next slides you will get more details about the individual steps of the analytical approach.



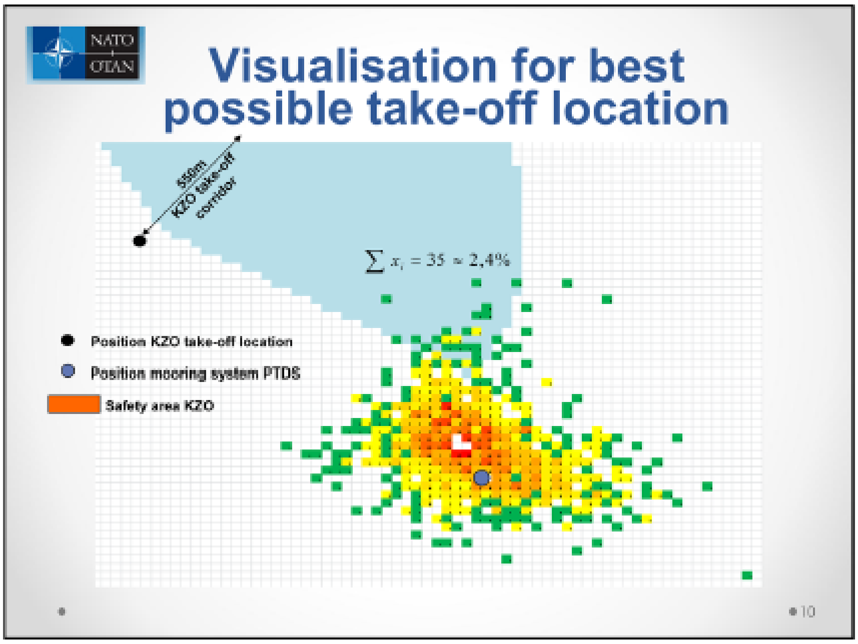
Here the histograms of the wind direction and wind speed are depicted. As you can see, wind from the northwest is quite frequent. Therefore, the data suggest a new take-off location northwest of the PTDS mooring system. In most cases the wind speed was relatively low and in 99% of all cases less than 20 knots. This is an important factor with regard to the deflection formula depicted on the next slide.



This picture was the only information the analysts had with regard to deflection of the PTDS. You can see the deflection for 3 separate altitudes in feet and the deflection for 25 and 50 knots wind speed. However, data were missing for a deflection at a wind speed of 5 knots. Additionally, the problem was not linear. The deflection formula at the bottom was specifically created by the analysts for this specific problem set. With this formula you can calculate the deflection for every height and wind speed.



Here you can see the visualized result for the risk analysis of the original take-off location. A coordinate system of boxes with a dimension of 50 feet (width/length) was used. The safety area of the KZO take-off location is shown in light blue. The analysis showed how often PTDS would have drifted into a box within the last 8 months. For better/easier understanding a heat map was used based on the numerical data. Green color means that the PTDS drifted rarely in a specific box. Red means that it drifted very often in this box. You can see that the original take-off location is in close proximity of the PTDS. The data clearly show the criticality. As you can see with a probability of 22,5% the PTDS would have interfered with the safety area of the KZO. This high risk is not acceptable.



Here you see in comparison the results of the best possible (with regard to local restrictions) take-off location. The probability that the PTDS will drift into the safety area of the KZO reduced to 2,4% from over 20%, as seen on the previous slide. Additional, in no case did the PTDS drift into the take-off corridor of the KZO. Based on this risk assessment, the commander's decision was to replace the original take-off location with this one.

What is Risk Assessment?

- Risk assessment is the determination of quantitative and / or qualitative value of risk related to a concrete situation and a recognized threat (also called hazard).
- In our case, to determine the risk that the PTDS will drift into the safety area of the KZO.
- For the analysis mathematic and statistic elements were used.

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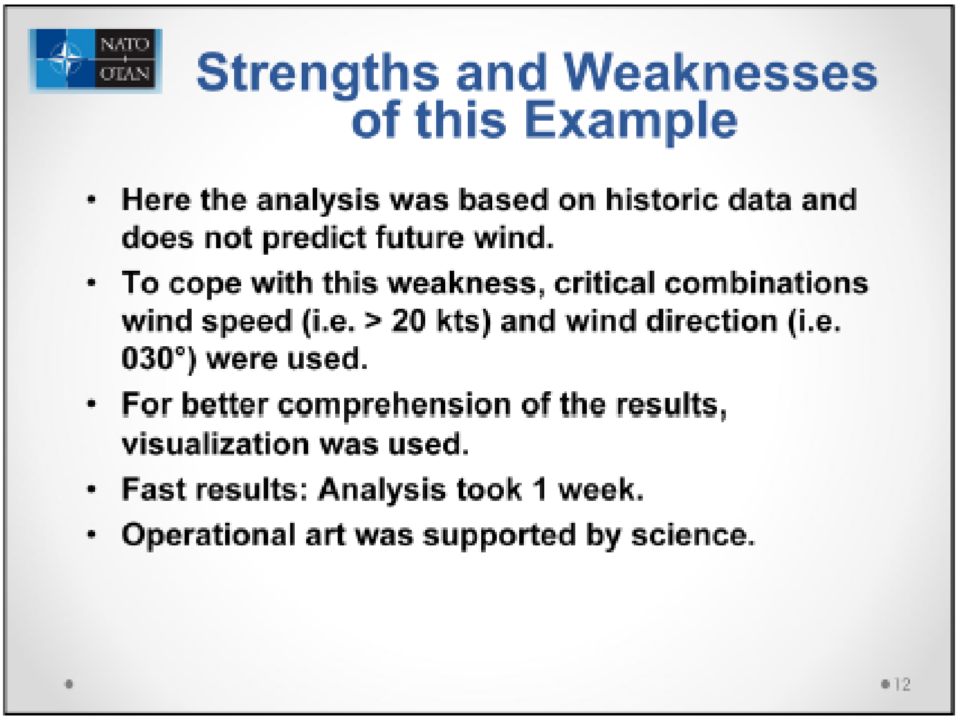
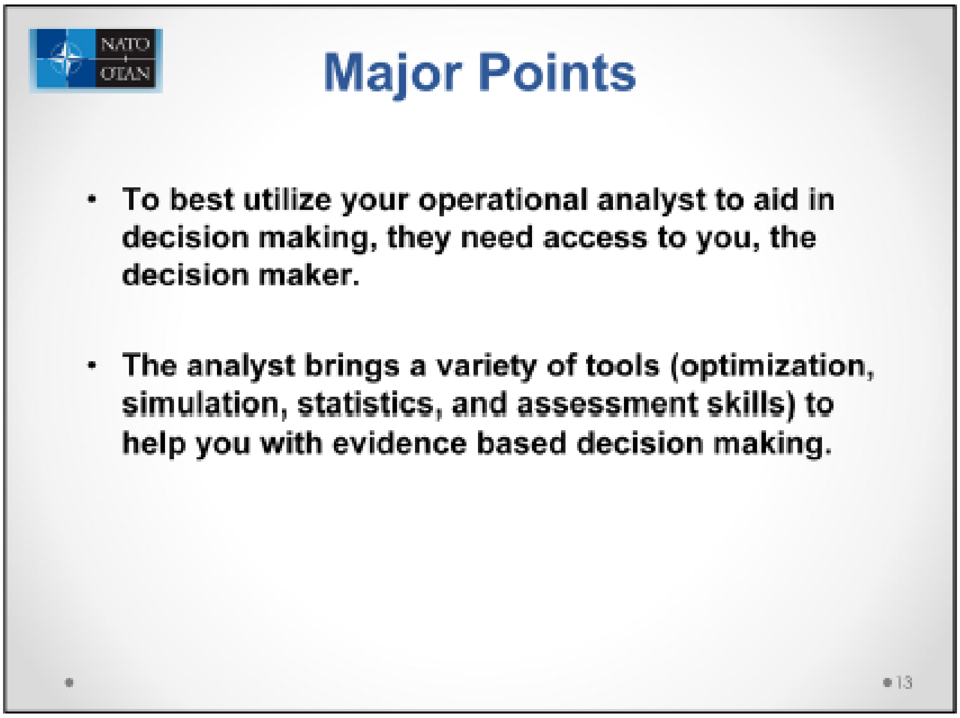

NATO OTAN
Strengths and Weaknesses of this Example
• Here the analysis was based on historic data and does not predict future wind.
• To cope with this weakness, critical combinations wind speed (i.e. > 20 kts) and wind direction (i.e. 030°) were used.
• For better comprehension of the results, visualization was used.
• Fast results: Analysis took 1 week.
• Operational art was supported by science.
12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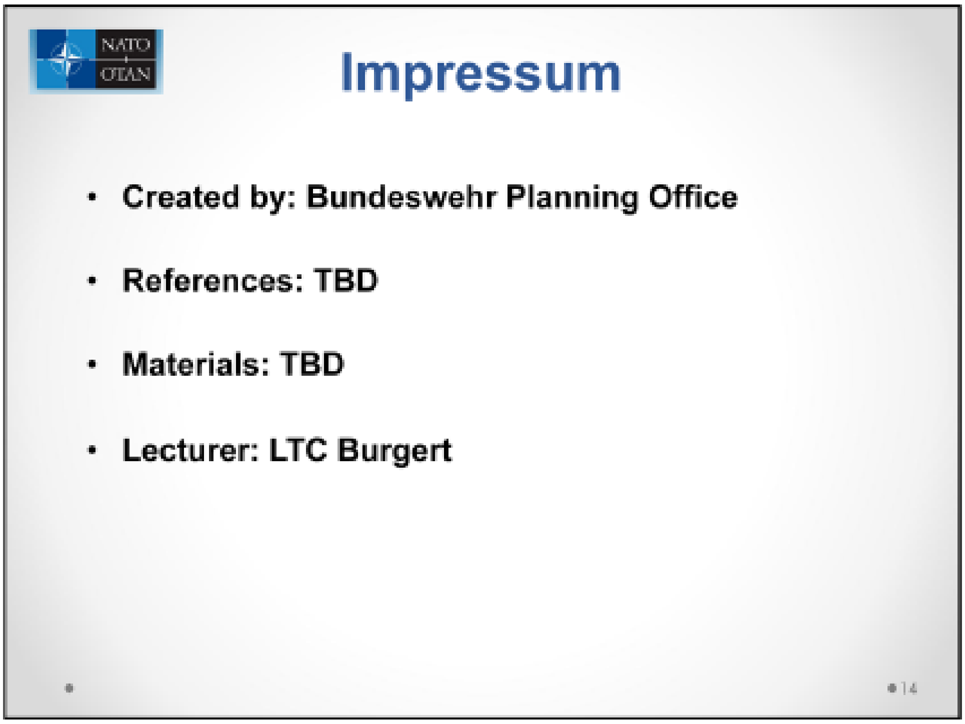
Major Points
• To best utilize your operational analyst to aid in decision making, they need access to you, the decision maker.
• The analyst brings a variety of tools (optimization, simulation, statistics, and assessment skills) to help you with evidence based decision making.
13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Impressum
• Created by: Bundeswehr Planning Office
• References: TBD
• Materials: TBD
• Lecturer: LTC Burgert
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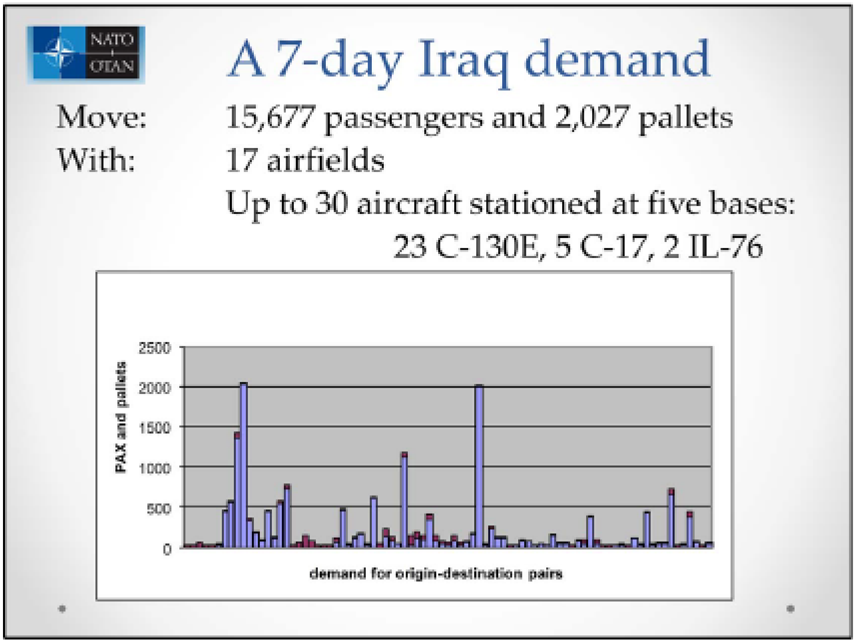
A.2.3 Intra-Theatre Airlift

INSTRUCTIONAL MODULE SUMMARY

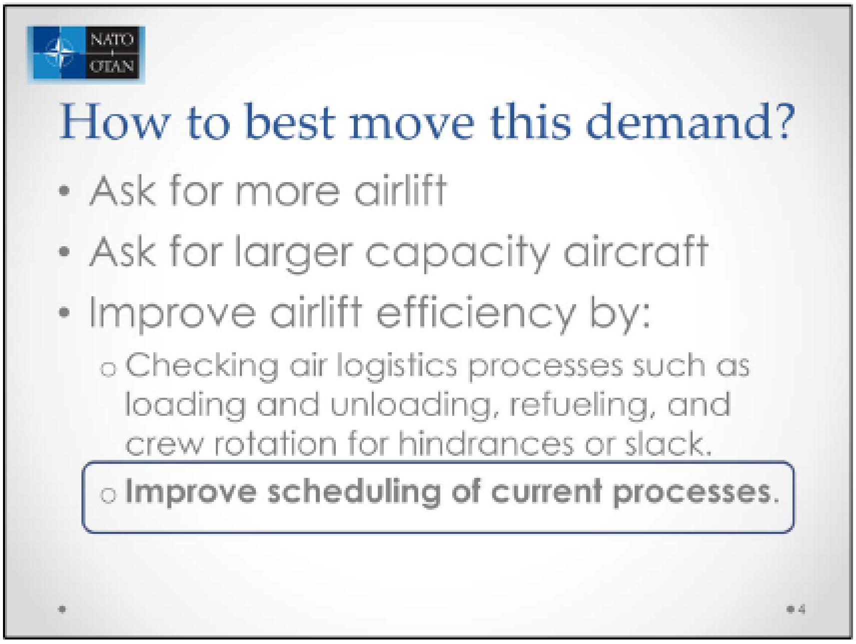
Title	Using Operational Analysis to Improve Intra-Theater Lift: A Case Study in Optimization
Level	Operational
Faculty Name(s)	Robert Dell, Naval Postgraduate School, Monterey, California, USA
Length	20 – 30 Minute General Briefing; 40 – 60 minutes Specialist Briefing
Learning Objectives	Understand how optimization can contribute to efficient scheduling in operations. Understand the concept of optimization (exact and heuristic). Appreciate its contribution in a complex planning environment. Understand through case example the use of optimization in logistics scheduling.
Outcomes	As the result of this module, participants will be able to: Appreciate the uses of optimization in logistics scheduling and understand its strengths and limitations.
Content Outline	Case Study: Intra-theater airlift. Optimization and Heuristic Defined.
Materials	List Required Pre-Readings: None.
Methods	100% Lecture 0% Class Exercises. _____% Break Outs.
Exercise(s)	Seminar participants will be asked to evaluate charts and outputs from each case study.
Break Outs	___ Yes X No. __#___ participants in each break out group.
Discussion Questions	What are your experiences with manual scheduling? How might optimization improve that process?

This presentation shows a case study in the use of operational analysis to improve intra-theater air lift scheduling during the Iraq conflict.

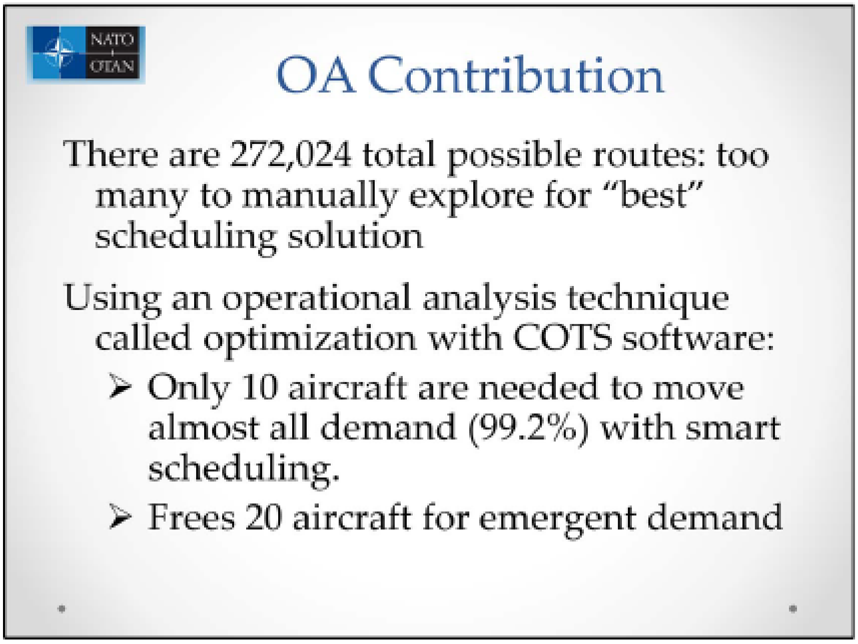
In 2005 the IED threat was growing to truck conveys carrying supplies to forward operating bases in Iraq. To avoid ground troop exposure to IEDs, it was the desire to move as many supplies as possible via air lift. As we will see, using operational analysis techniques of optimization, an improved air lift schedule was created that actually freed aircraft for more scheduling.



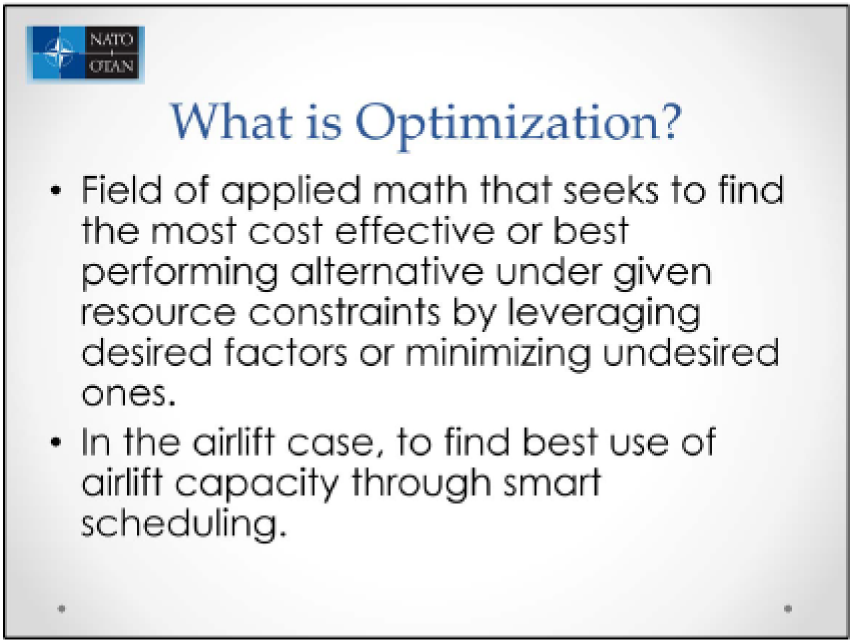
This is a snap shot of the problem. This is a typical 7-day demand schedule showing the number of PAX and pallets requested for movement between specific origins and destinations. This week we can see a request to move a total of over 15,000 passengers and over 2000 pallets. The theater air assets to accomplish this 17 destination airfields, and thirty lift aircraft stationed at five bases.



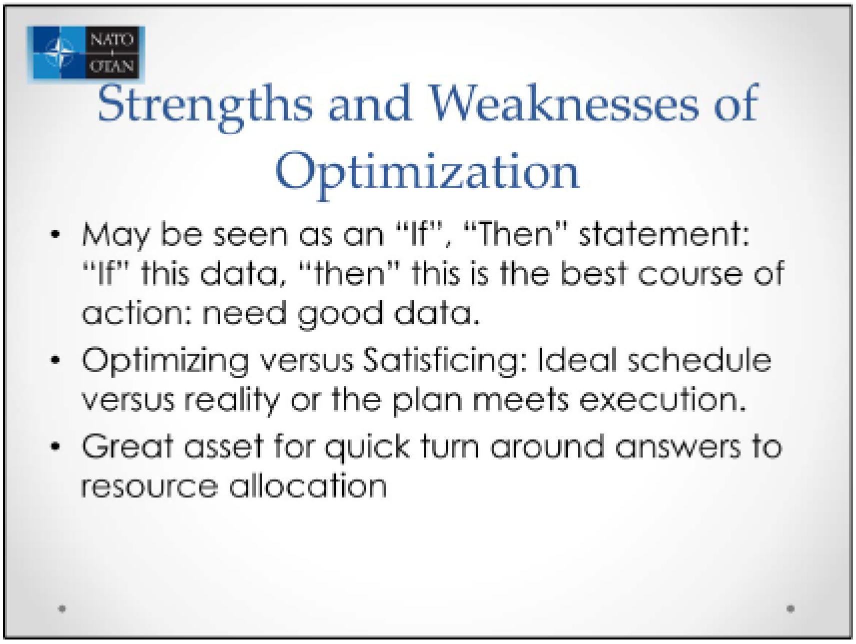
Alternatives to lift this demand are listed on the slide. Although all were considered, this study focuses on improving the scheduling of the air lift processes.



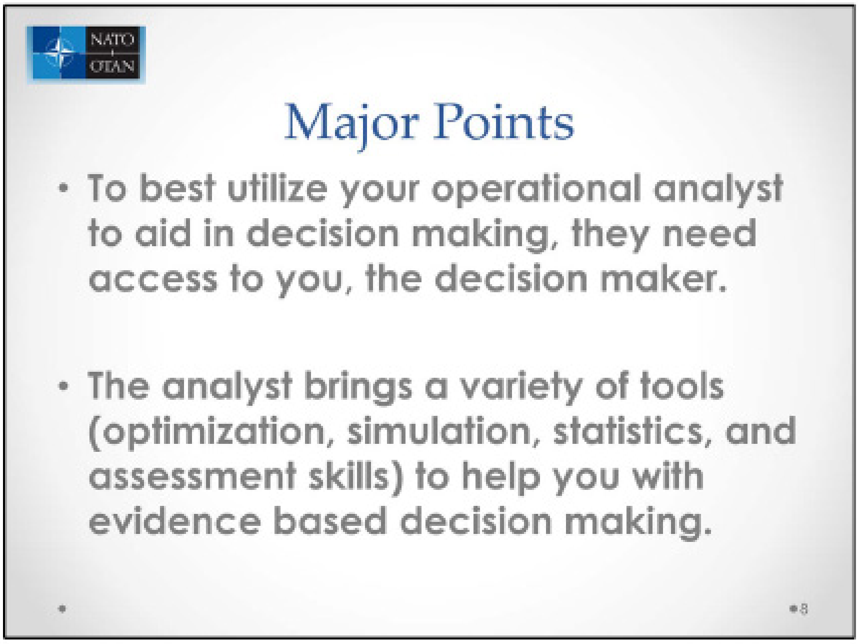
With all possible aircraft and air base assignments, manually exploring all alternatives to find the best schedule to move demand in near impossible. Using optimization, however, the analysts produced a scheduling tool that resulted in lifting over 99% of the demand with on only 10 aircraft. This freed up 20 aircraft for addition lift requirements.



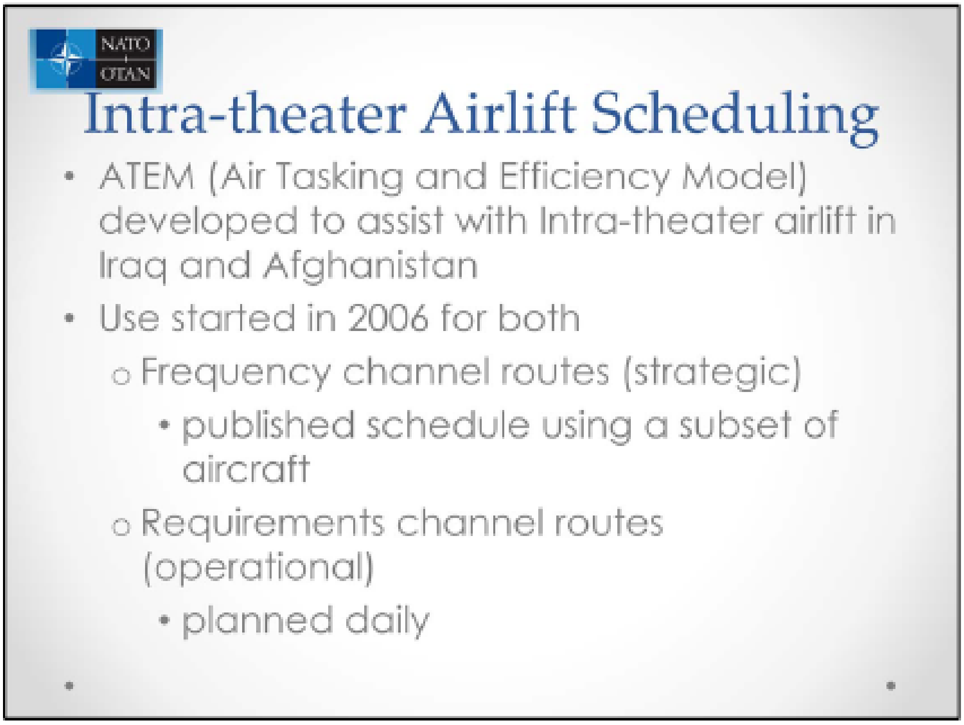
The field of optimization can be applied in many ways: from scheduling to assignment problems. It usually requires an analyst familiar with the tool, and an operator that understands the system to be optimized.



A very valuable use of optimization is applying it to "What if" problems. If this assumption or data set is true, what is the best we can do compared to if another assumption or data set is true. Another case study example of this is scheduling combat logistics force ships in the U.S. Fifth Fleet AOR where the commander needed to understand the impact of losing an oil replenishment ship.



The following slides may be used for more detail to the problem. They show flight routes, bases, air assets and capabilities and provide the formulation for ATEM, the air scheduling model.



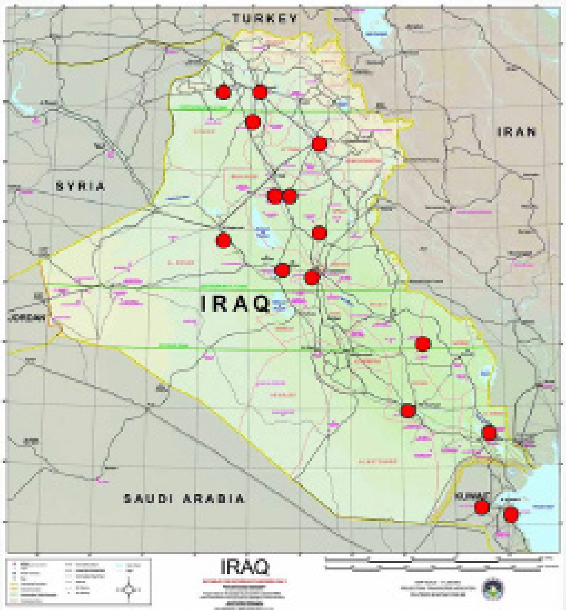
NATO OTAN

Schedule What?

- Intra-theater airlift of two basic commodities:
  - Pallets (PALS)
  - Passengers (PAX)
- … between 17 airfields …
- … using three basic airframes:
  - C-17 ($200M each)
  - C-130E ($40M each), J1, J2
  - IL-76 (contract aircraft)
- Goal: Move as much materiel as possible

NATO OTAN

Schedule Where?



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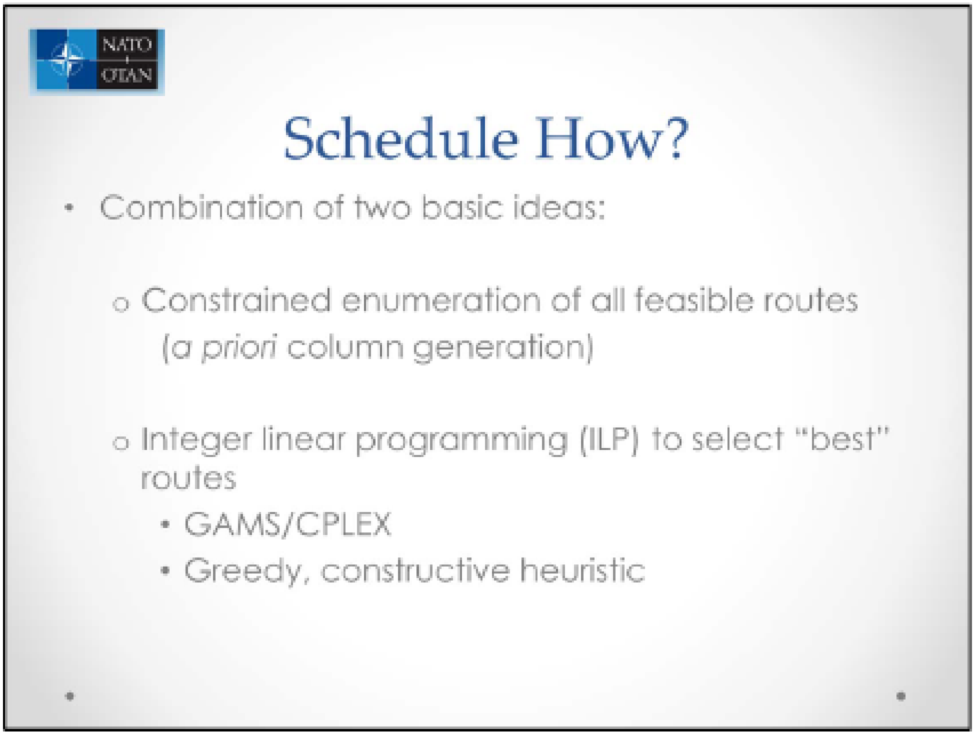
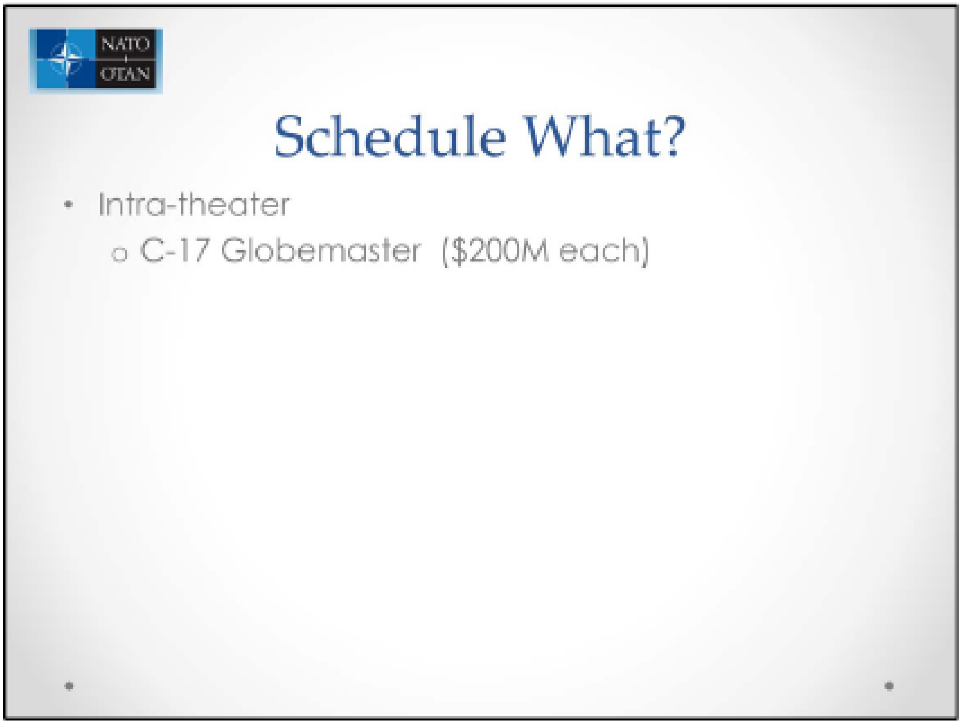

Schedule How?
• Combination of two basic ideas:
○ Constrained enumeration of all feasible routes (*a priori* column generation)
○ Integer linear programming (ILP) to select "best" routes
• GAMS/CPLEX
• Greedy, constructive heuristic

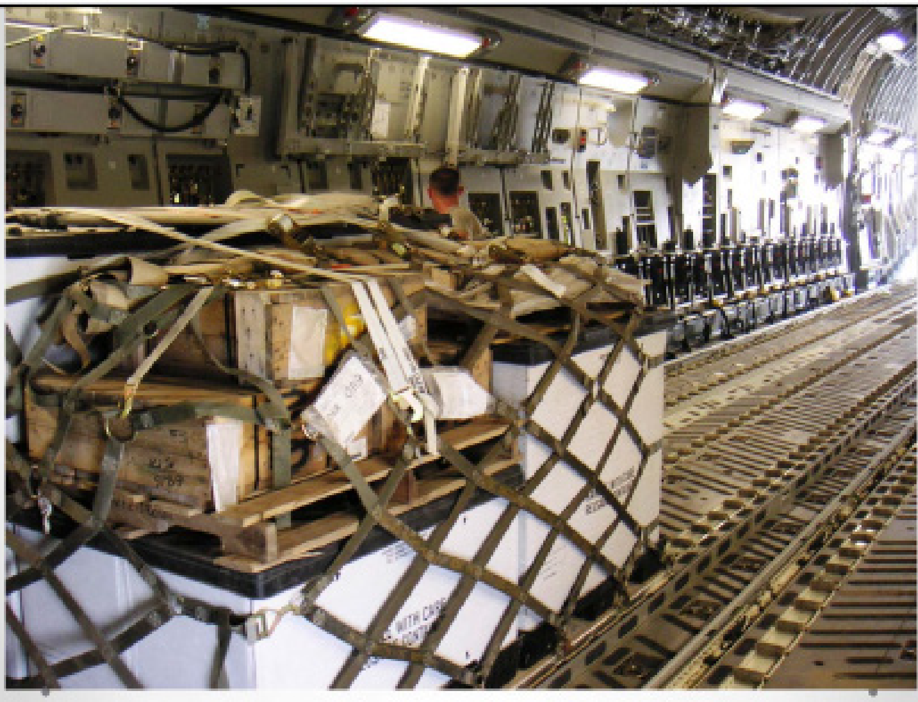

Schedule What?
• Intra-theater
○ C-17 Globemaster ($200M each)


U.S. AIR FORCE
4129

C-17 Configurations

conf	pax	pals
c17c	0	18
c17cp	54	11
c17p	189	4

Must also select a configuration for each aircraft on each route



NATO OTAN

Schedule What?

- Intra-theater
  - C-17 ($200M each)
  - C-130E ($40M each), J1, J2

C-130E Configurations

conf	pax	pals
apc2	9	5
apc3	25	4
apc4	42	3
apc5	56	2
apc6	72	0

C-130J Configurations

conf	pax	pals
jac2	0	8
jacp2	18	7
jacp3	34	6
jacp4	50	5
jacp5	60	4
jacp6	74	3
jacp7	94	2
jap1	115	1

Schedule What?

- Intra-theater
  - C-17 ($200M each)
  - C-130E ($40M each), J1, J2
  - IL-76 (contract aircraft)

IL-76 Configuration

conf	pax	pals
	0	9

Schedule What?

- Intra-theater
    - C-17 ($200M each)
    - C-130E ($40M each), J1, J2
    - IL-76
- itinerant C-5

Move What?

line	APOE	APOD	PAX	PALS	Line Importance
l1	A	C	549	13	1
l2	A	E	98	15	1
l3	A	B	28	6	1
l4	A	F	83	12	1
l5	D	C	646	23	1
l6	D	B	13	7	1
l7	C	A	674	21	1
l8	C	D	567	27	1
l9	C	E	827	44	1
l10	C	G	258	3	1

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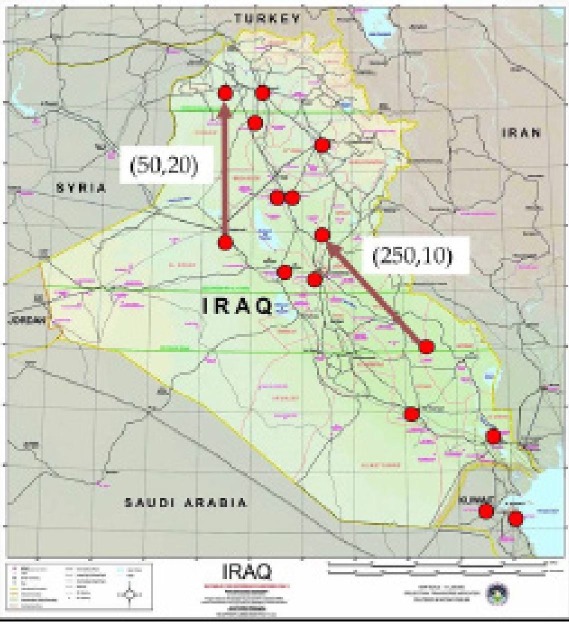
Demand Lines



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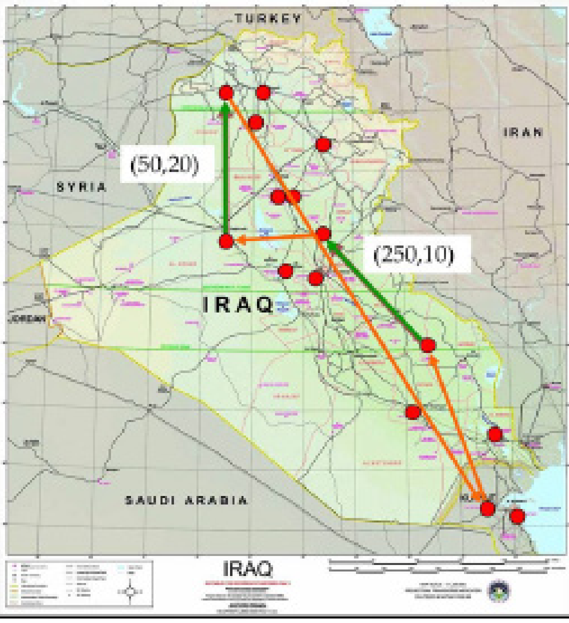
Routes



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How to route?

- Aircraft must start and end at same airport
- Time between airports by aircraft type
- Ground time by aircraft type and airport
- Refueling time by aircraft type and airport
- Maximum landings in the box before recrewing
- Demand line "throughput" allowed

Operating Limits

	C-17	C-130E
Mx route hrs	10.0	8.0
Mx hrs bef refuel	10.0	5.0
Mn hrs bef refuel	10.0	3.0
Mx lands in "box"	5	20
Mx recrews	1	0

Aircraft and Cargo

- up to 35 aircraft
  - up to five types
  - multiple configurations
- 17 airfields
  - five home airfields
- cargo types
  - passengers
  - pallets

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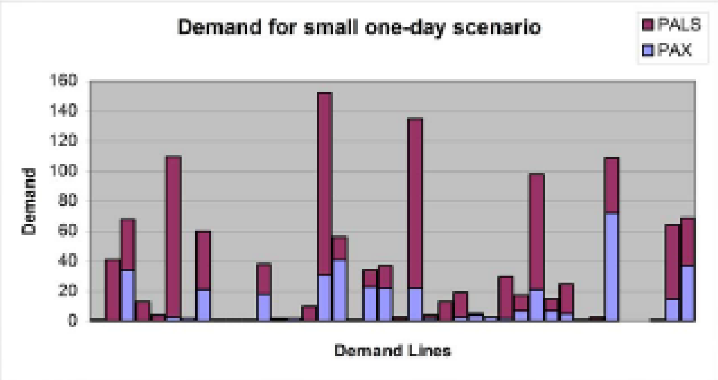
How many routes?

- For a fleet consisting of:
  - Thirty planes…
  - … of three basic plane_types…
    - C-17, C-130E, IL-76
  - … based at five starting airfields…
- We get a few hundred thousand routes to consider
- Use an optimization model to select the best set
- A developed heuristic can select a good set. The heuristic has no solution guarantee (don't know if you can do better) but it is quicker and doesn't require special software

1-day Afghanistan example

40 demand lines: 404 passengers, 844 pallets
14 airfields
14 aircraft at two home airfields: 6 C-130E, 8 C-17



1-day Afghanistan example

1,916 total routes

3 secs to find optimal solution (ILP)

less time using the heuristic

both heuristic and ILP solutions move

- 155 of 404 passengers
- 398 of 844 pallets
- only ILP lets you know that you can't do better

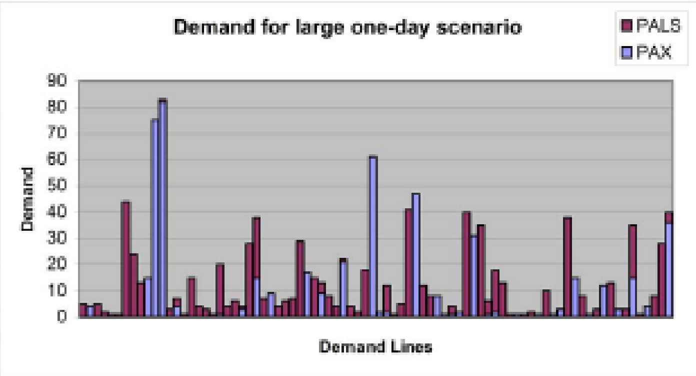
1-day Iraq scenario

82 demand lines: 505 passengers, 645 pallets

17 airfields

29 aircraft at five home airfields:

22 C-130E, 5 C-17, 2 IL-76

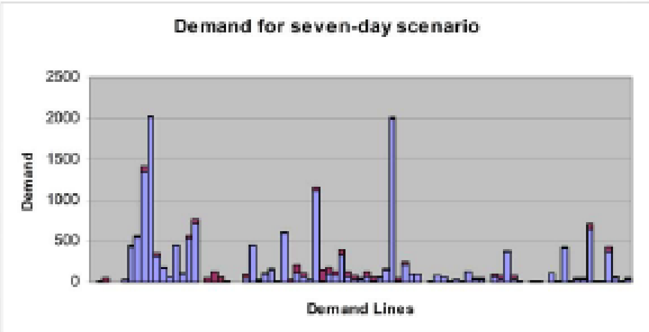


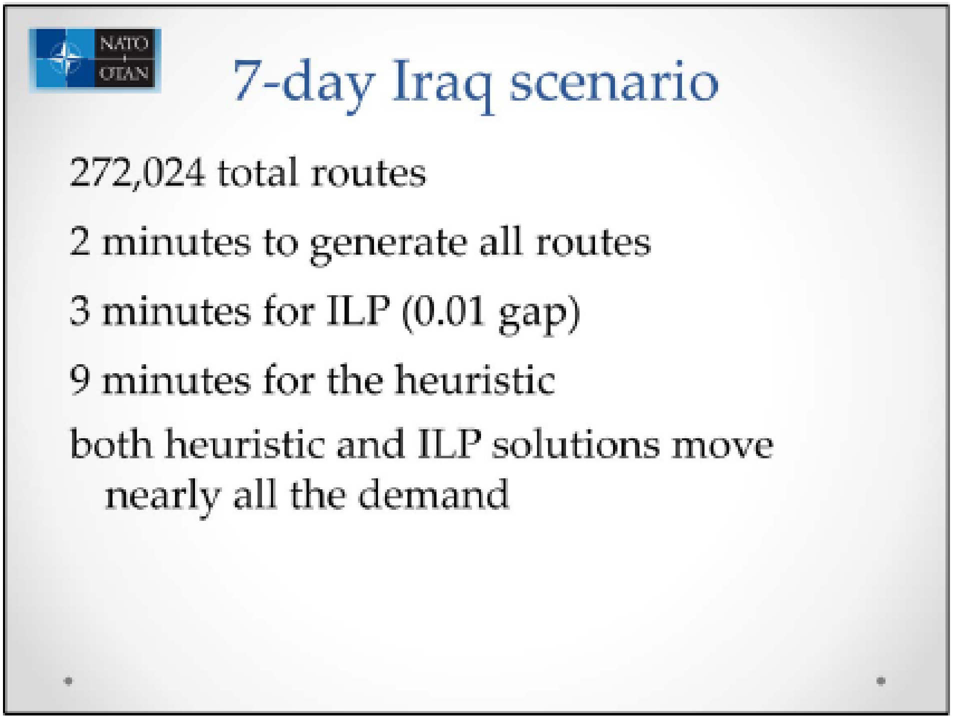
1-day Iraq scenario

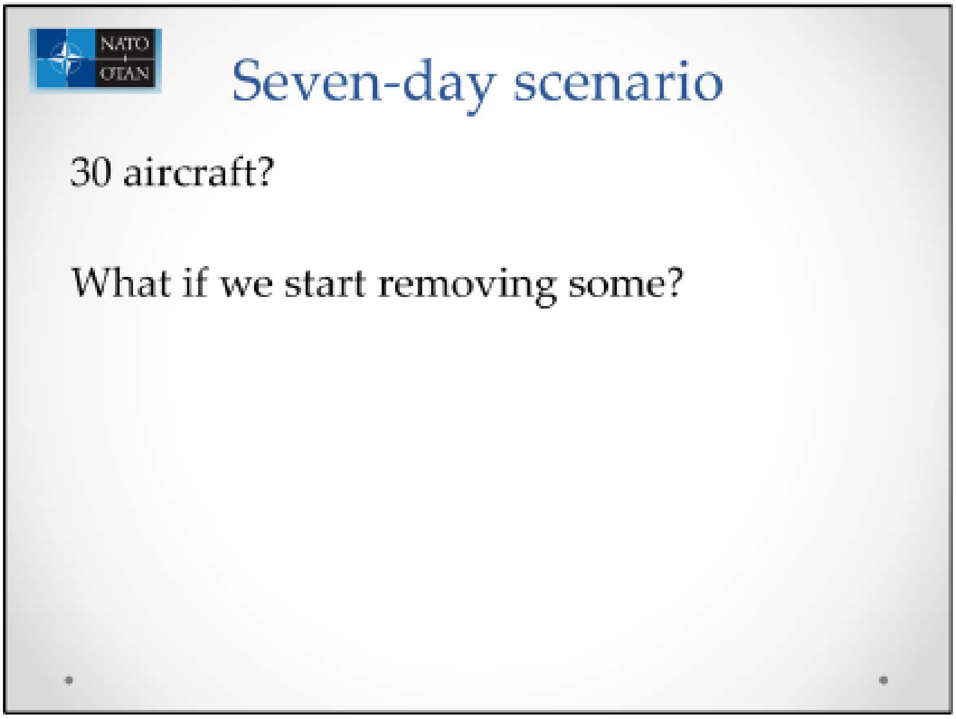
207,121 total routes
2 minutes to generate all routes
40 minutes for ILP (0.01 gap)
3 minutes for the heuristic
ATEM ILP moves
– 445 of 505 passengers (88%)
– 614 of 645 pallets (95%)
ATEM heuristic moves
– 456 of 505 passengers (90%)
– 588 of 645 pallets (91%)

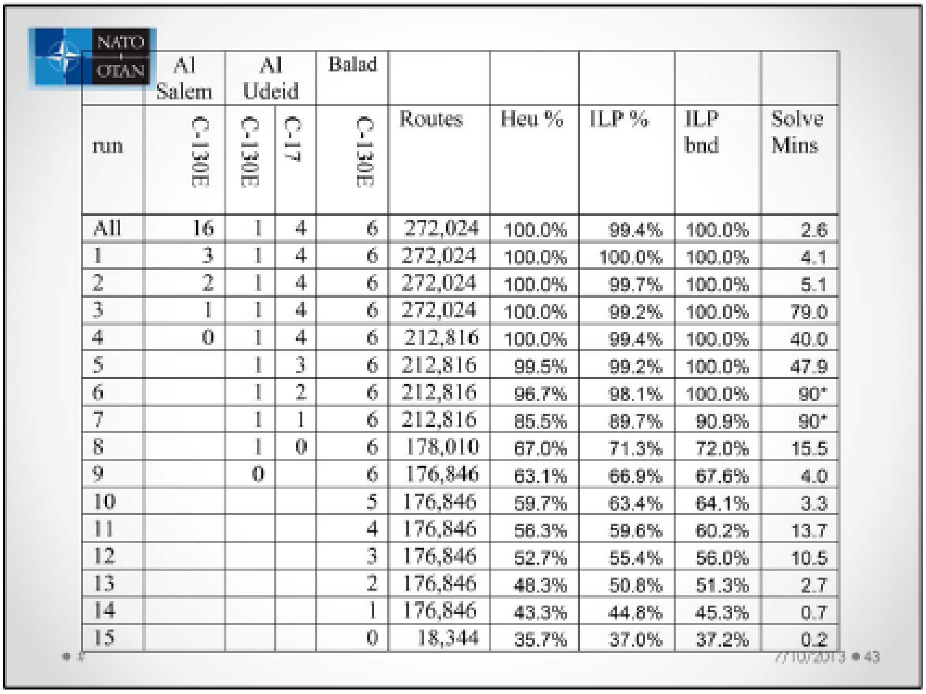
7-day Iraq scenario

85 demand lines: 15,677 passengers, 2,027 pallets
17 airfields
30 aircraft at five home bases:
23 C-130E, 5 C-17, 2 IL-76

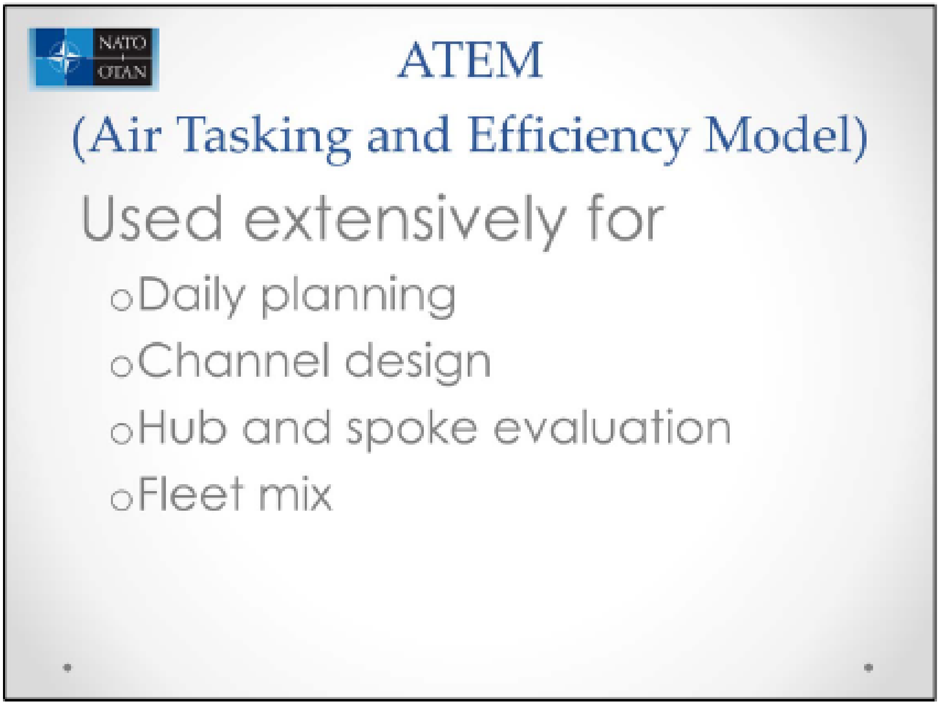



7-day Iraq scenario
272,024 total routes
2 minutes to generate all routes
3 minutes for ILP (0.01 gap)
9 minutes for the heuristic
both heuristic and ILP solutions move nearly all the demand


Seven-day scenario
30 aircraft?
What if we start removing some?



run	Al Salem C-130E	Al Udeid C-130E	Al Udeid C-17	Balad C-130E	Routes	Heu %	ILP %	ILP bnd	Solve Mins
All	16	1	4	6	272,024	100.0%	99.4%	100.0%	2.6
1	3	1	4	6	272,024	100.0%	100.0%	100.0%	4.1
2	2	1	4	6	272,024	100.0%	99.7%	100.0%	5.1
3	1	1	4	6	272,024	100.0%	99.2%	100.0%	79.0
4	0	1	4	6	212,816	100.0%	99.4%	100.0%	40.0
5		1	3	6	212,816	99.5%	99.2%	100.0%	47.9
6		1	2	6	212,816	96.7%	98.1%	100.0%	90*
7		1	1	6	212,816	85.5%	89.7%	90.9%	90*
8		1	0	6	178,010	67.0%	71.3%	72.0%	15.5
9		0		6	176,846	63.1%	66.9%	67.6%	4.0
10				5	176,846	59.7%	63.4%	64.1%	3.3
11				4	176,846	56.3%	59.6%	60.2%	13.7
12				3	176,846	52.7%	55.4%	56.0%	10.5
13				2	176,846	48.3%	50.8%	51.3%	2.7
14				1	176,846	43.3%	44.8%	45.3%	0.7
15				0	18,344	35.7%	37.0%	37.2%	0.2



Indices and index sets

$a \in A$	set of airfield APOs $[\sim 20]$
$c \in C$	set of cargo types (passengers and cargo pallets) $[\sim 2]$
$p \in P$	set of plane types $[\sim 5]$
$p \in P_a$	set of planes of type p based as airfield a
$g \in G_p$	set of configurations for plane type p $[\sim 5]$
$l \in L$	set of flight legs or segments (APOE, APOD pairs) $[\sim 100]$
$a(l)$	airfield a is origin (APOE) of leg l
$a'(l)$	airfield a' is destination (APOD) for leg l
$r \in R_{pa}$	set of routes for plane type p at airfield a $[\leq 100,000]$
$s^o = 1,2,...S$	ordinal of stop [~7]
$s \in S_r$	set of take-offs on route r (i.e., $s^o = 1,2,...S-1$)
$s' \in S'_r$	set of landings on route r (i.e., $s^o = 2,...S$)
$a(r,s)$	airfield a is stop s on route r
$p(r)$	plane type for route r
$g(r)$	load configuration for route r

Data

$carry_{lcr}$	amount of cargo c on leg l that can be airlifted by route r
cp_{lc}	priority of cargo c on leg l
dem_{lc}	demand units of demand line l for cargo c
cap_{gc}	capacity of configuration g for cargo type c
$\overline{landing}_a$	maximum number of landings in APO a
$planes_{pa}$	number of plane type p starting from APO airfield a
$sieve$	maximum number of routes to select for each plane type p in each configuration g starting from each airfield a

Variables

$SELECT_r$ — integer number of times plane type $p(r)$ is flown on route r

$EXTRA_{lc}$ — integer capacity of selected routes to take extra cargo c, leg l demand if available

$LOAD_{rss'c}$ — integer cargo units airlifted by plane type $p(r)$ flying route r from APOE airfield s to APOD airfield s' of cargo type c

Without Throughput

Maximize

$$\sum_{lcr} cp_{lc} \cdot carry_{lcr}\, SELECT_r - \sum_{lc} cp_{lc}\, EXTRA_{lc}$$

Subject to:

$$\sum_{r \in R_{pa}} SELECT_r \le planes_{pa} \qquad \forall a, p \in P_a$$

$$\sum_{r} carry_{lcr} SELECT_r \le dem_{lc} + EXTRA_{lc} \qquad \forall l, c$$

$$\sum_{\substack{r,\\ s' \in S'_r | a = a(r,s')}} SELECT_r \le \overline{landing}_a \qquad \forall a$$

With Throughput

Subject to:

$$\sum_{r \in R_{pa}} SELECT_r \le planes_{pa} \qquad \forall a, p \in P_a$$

$$\sum_{\substack{r, \\ s \in S_r | a(r,s)=a(l), \\ s' \in S_r | a(r,s')=a'(l) \\ \wedge s < s'}} LOAD_{rss'c} \le dem_{lc} \qquad \forall l, c$$

$$\sum_{\substack{s \in S_r | s \le s^o \\ s' \in S'_r | s' > s^o}} LOAD_{rss'c} \le cap_{g(r)c}\, SELECT_r \qquad \forall r, s^o \in S_r, c$$

$$\sum_{\substack{r, \\ s' \in S'_r | a=a(r,s')}} SELECT_r \le \overline{landing_a} \qquad \forall a$$

With Throughput

Maximize

$$\sum_{\substack{r, s \in S_r, s' \in S'_r, \\ l | a(r,s)=a(l) \wedge a(r,s')=a'(l), \\ \wedge | s' > s, c}} cp_{cl} LOAD_{rss'c}$$

A.2.4 Peace Support and Game Theory

INSTRUCTIONAL MODULE SUMMARY

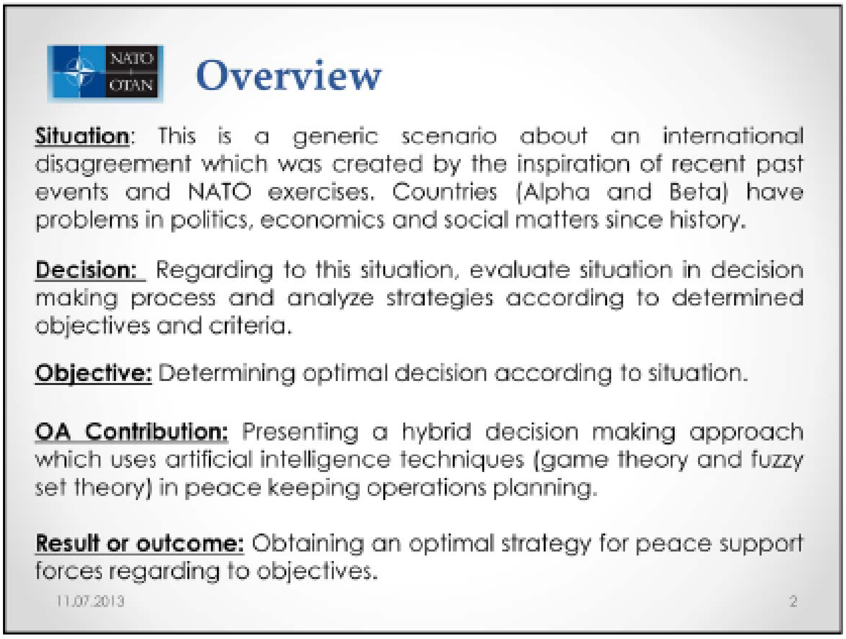
Title	Decision-Making Process in Peace Support Operations
Faculty Name(s)	Asst.Prof.Dr. Col. Hakan Soner APLAK, Turkish Military Academy, Ankara, Turkey
Length	75 – 90 minutes
Learning Objectives	Provide an approach for situation awareness. Provide a hybrid operational analysis approach for decision-making in uncertainty. Provide an analytic method for evaluation of strategies.
Outcomes	As the result of this module, participants will be able to: Analyze situation. Utilize the analysts to aid in operations and decisions in planning.
Content Outline	Information about situation. Proposed approach for decision-making. Contributions of OA to decisions. More Detailed information about application.
Materials	List Required Pre-Readings: Yager, R.R., "Multiple Objective Decision-Making Using Fuzzy Sets", International Journal of Man-Machine Studies, 1977. Chen S.J. and Hwang C.L., "Fuzzy Multiple Attribute Decision Making: Methods and Applications", Springer, New York, 1992. Ross, T., "Fuzzy Logic with Engineering Applications", 2nd Ed. John Willey & Sons Ltd., West Sussex, England, 2004. Godet, M., "Scenarios and Strategic Management", London Butterworth, 1987. Aplak, H.S., "Fuzzy Logic Based Game Theory Applications in Decision Making Process", Ph.D. Thesis, Gazi University, Institute of Science and Technology, 2010. Aplak, H.S. and Türkbey O., "Fuzzy Logic Based Game Theory Applications in Multi-Criteria Decision Making Process", Journal of Intelligent and Fuzzy Systems, 2013. Aplak, H.S. and Türkbey O., "The Application of Two Person Non-Constant Sum Games in Multi-Objective Decision Process", The Journal of the Faculty of Engineering and Architecture of Gazi University, 2013.

Methods	100% Lecture 0% Class Exercises. ____% Break Outs.
Exercise(s)	Participants will be ask to discuss relevancy of approaches to their past decision challenges.
Break Outs	___ Yes X No. __#___ participants in each break out group.
Discussion Questions	What are your experiences about peace keeping operations? How might game decision payoff matrix be obtained? How can analytical methods be used in DM process in uncertainty?

Peace Support Operation Planning (Game Theory Application in Decision Making Process)

A Case Study in Game Theory

Asst.Prof.Dr.Col. Hakan Soner APLAK
Turkish Military Academy



<u>Situation</u>: This is a generic scenario about an international disagreement which was created by the inspiration of recent past events and NATO exercises. Countries (Alpha and Beta) have problems in politics, economics and social matters since history.

<u>Decision:</u> Regarding to this situation, evaluate situation in decision making process and analyze strategies according to determined criteria.

<u>Objective:</u> Determining optimal decision according to situation.

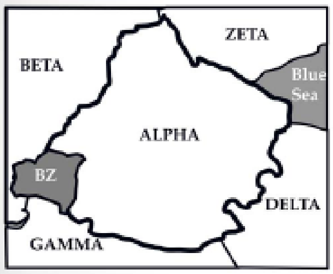
<u>OA Contribution:</u> Presenting a hybrid decision making approach which uses artificial intelligence techniques (game theory and fuzzy logic system) in peace keeping operations planning.

<u>Result or outcome:</u> Obtaining an optimal strategy for peace support forces regarding to objectives.

This is a generic scenario about an international disagreement.

It includes a peace support operation planning.

Situation



- Countries (Alpha and Beta) are in disagreements in politics, economics and social matters since history.
- Beta claims that Buffer Zone (BZ) area which has plenty of natural sources, belongs to it.
- Alpha call for an international aid against Beta's demand. United Nations send and located international peace support force to control the area.

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The formed case is a generic scenario and about an international disagreement between two countries. It can be summarized as follows;

* Countries (Alpha and Beta) have problems in politics, economics and social matters since history.

* Especially, Beta claims that Buffer Zone (BZ) area which has plenty of natural sources, belongs to it.

* For this reason, Alpha call for an international aid against Beta's demand. United Nations send and located international peace support force to control the area, especially buffer zone.

Approach

- The situation is analyzed in two person non-constant sum game theory perspective and a hybrid decision making approach is used for Decision Making Process (DMP).
- Qualitative and quantitative methods are used to merge intuitions, experiences, preferences and knowledge of decision makers (DMs).

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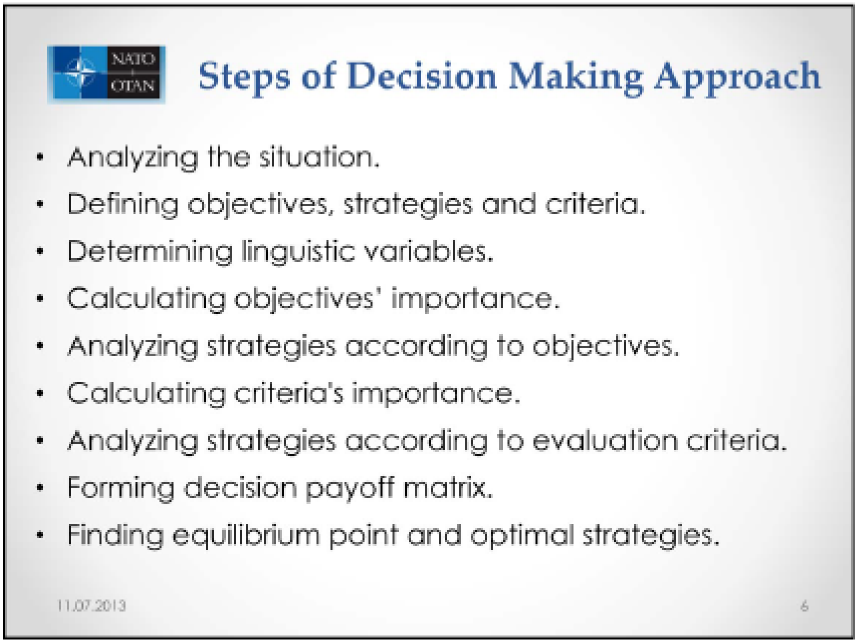
* The situation is analyzed in two person non-constant sum game theory perspective and a hybrid decision making approach is used for Decision Making Process (DMP).

* Qualitative and quantitative methods are used to merge intuitions, experiences, preferences and knowledge of decision makers (DMs).



Steps of proposed decision making approach are;

* Analyzing the situation.

* Defining objectives, strategies and criteria.

* Determining linguistic variables.

* Calculating objective importance.

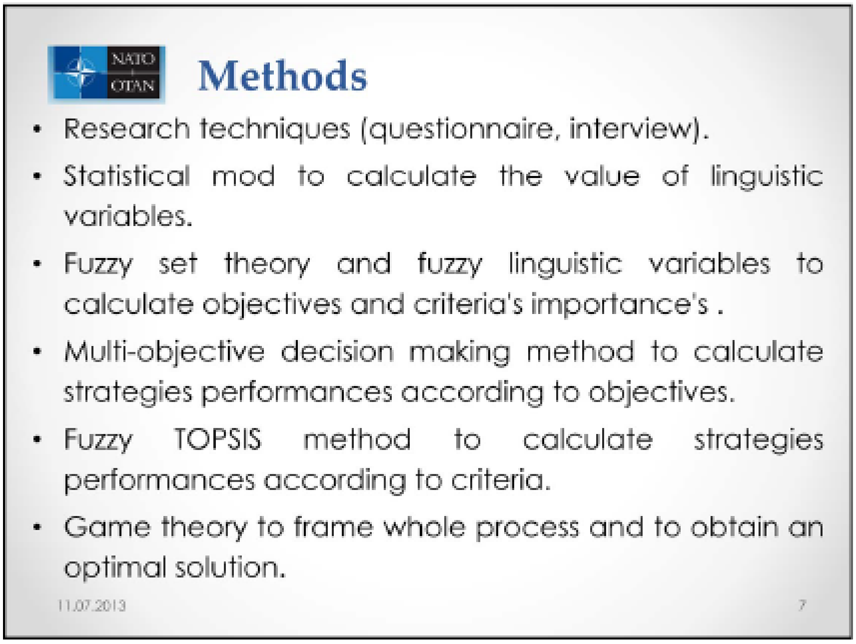
* Analyzing strategies according to objectives.

* Calculating criteria's importance.

* Analyzing strategies according to evaluation criteria.

* Forming decision payoff matrix.

* Finding equilibrium point and optimal strategies.



Methods which are used in this approach;

* Research techniques (questionnaire, interview).

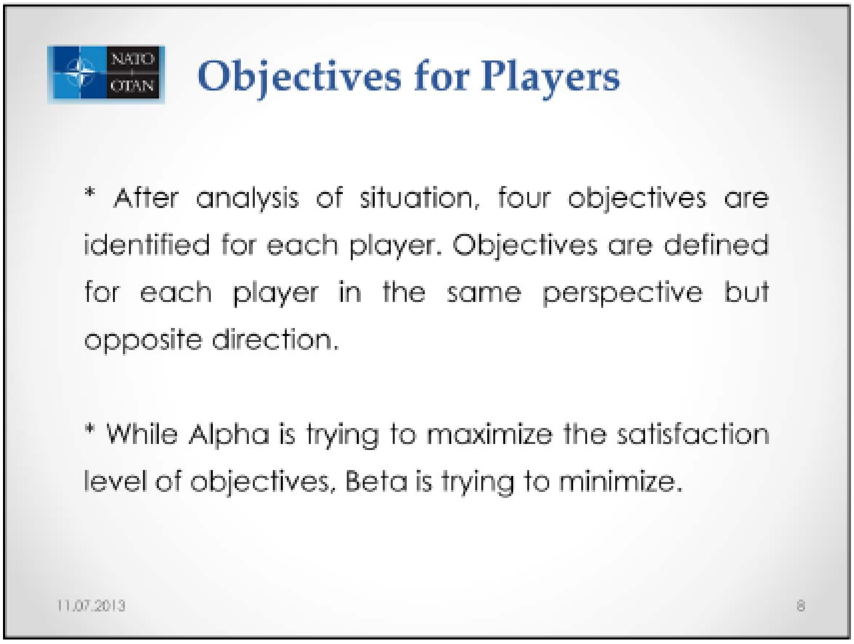
* Statistical mod to calculate the value of linguistic variables.

* Fuzzy set theory and fuzzy linguistic variables to calculate objectives and criteria's importance's.

* Multi-objective decision making method to calculate strategies performances according to objectives.

* Fuzzy TOPSIS method to calculate strategies performances according to criteria.

* Game Theory to frame whole process and to obtain an optimal solution.



* Decision making group (DMG) is consisted by experts who have similarity in their education level and had experiences about case.
* Situation is analyzed by DMG, then objectives and strategies of players are identified.

* After analysis of situation, four objectives are identified for each player. Objectives are defined for each player in the same perspective but opposite direction.

* While Alpha is trying to maximize the satisfaction level of objectives, Beta is trying to minimize.

Objectives of Alpha Player:

* Protecting Buffer Zone

* Protecting whole responsibility area

* Controlling in/out public opinion

* Peace keeping

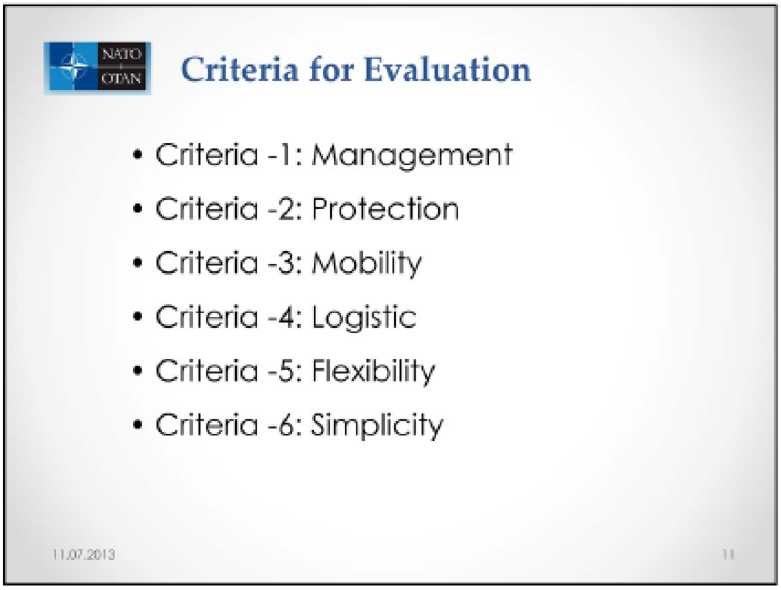
In this step, five strategies for Alpha (AS), four strategies for Beta player (BS) are listed.

Alpha;

- Main and rear area control
- Sector control
- Area control as whole
- Strong area control as whole
- Area control with local forces

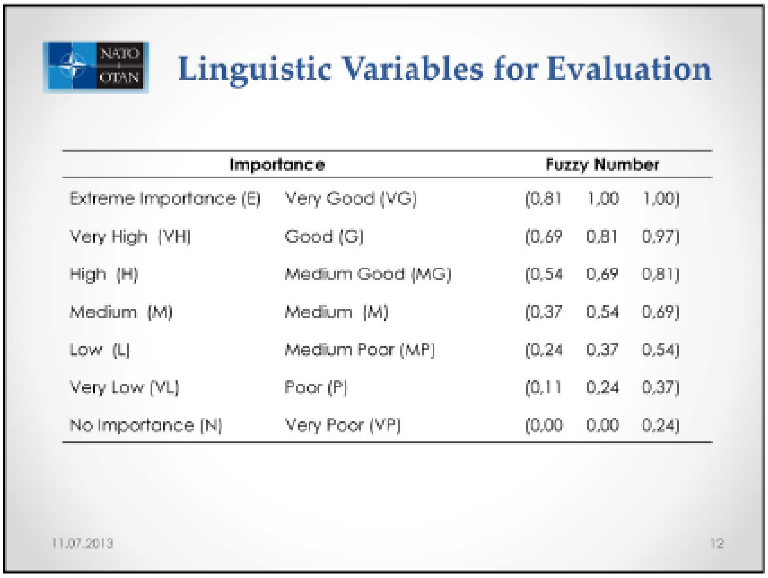
Beta;

- Attack by itself
- Corporate attack
- Passive attitude
- Ownership of conflict zone (BZ)



Then, key criteria are determined by using Godet's Scenario Planning sub method "structure analysis".

* Criteria -1: Management
* Criteria -2: Protection
* Criteria -3: Mobility
* Criteria -4: Logistic
* Criteria -5: Flexibility
* Criteria -6: Simplicity


Linguistic Variables for Evaluation

Importance		Fuzzy Number		
Extreme Importance (E)	Very Good (VG)	(0,81	1,00	1,00)
Very High (VH)	Good (G)	(0,69	0,81	0,97)
High (H)	Medium Good (MG)	(0,54	0,69	0,81)
Medium (M)	Medium (M)	(0,37	0,54	0,69)
Low (L)	Medium Poor (MP)	(0,24	0,37	0,54)
Very Low (VL)	Poor (P)	(0,11	0,24	0,37)
No Importance (N)	Very Poor (VP)	(0,00	0,00	0,24)

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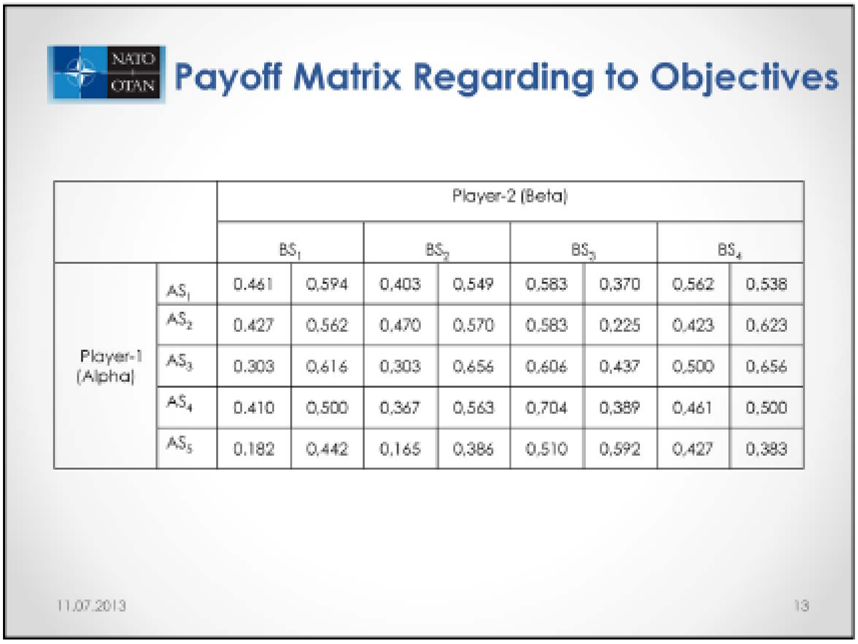
* A questionnaire is applied to DMG to determine linguistic variable's scale.
* Triangular Fuzzy Numbers (TFN) are used for describing the values of linguistic variables which are computationally efficient for DMP.
* After getting subjective assessments from DMG, these are aggregated by using statistical mod.



Payoff Matrix Regarding to Objectives

		Player-2 (Beta)							
		BS_1		BS_2		BS_3		BS_4	
Player-1 (Alpha)	AS_1	0.461	0.594	0.403	0.549	0.583	0.370	0.562	0.538
	AS_2	0.427	0.562	0.470	0.570	0.583	0.225	0.423	0.623
	AS_3	0.303	0.616	0.303	0.656	0.606	0.437	0.500	0.656
	AS_4	0.410	0.500	0.367	0.563	0.704	0.389	0.461	0.500
	AS_5	0.182	0.442	0.165	0.386	0.510	0.592	0.427	0.383

* Multi-objective decision making (Yager, 1977) method is applied in this phase of methodology.
* First, the objectives are evaluated for each player and importance's are calculated by using linguistic variables by DMG.
* Second, the strategies of each player are evaluated according to objectives. This step is implemented in game theory perspective and strategies are compared with other player's strategies reciprocally.
* Finally, importance and performance coefficients are combined and a final coefficient is calculated which indicates the performance of each strategy for the satisfaction of objectives.

Payoff Matrix Regarding to Criteria

		Player-2 (Beta)							
		BS_1		BS_2		BS_3		BS_4	
Player-1 (Alpha)	AS_1	0,519	0,465	0,510	0,432	0,500	0,489	0,507	0,546
	AS_2	0,510	0,472	0,554	0,423	0,489	0,451	0,451	0, 552
	AS_3	0,352	0,477	0,373	0,431	0,505	0,488	0,487	0,540
	AS_4	0,375	0,465	0,391	0,480	0,517	0,489	0,469	0,500
	AS_5	0,338	0,507	0,322	0,441	0,554	0,520	0,531	0,513

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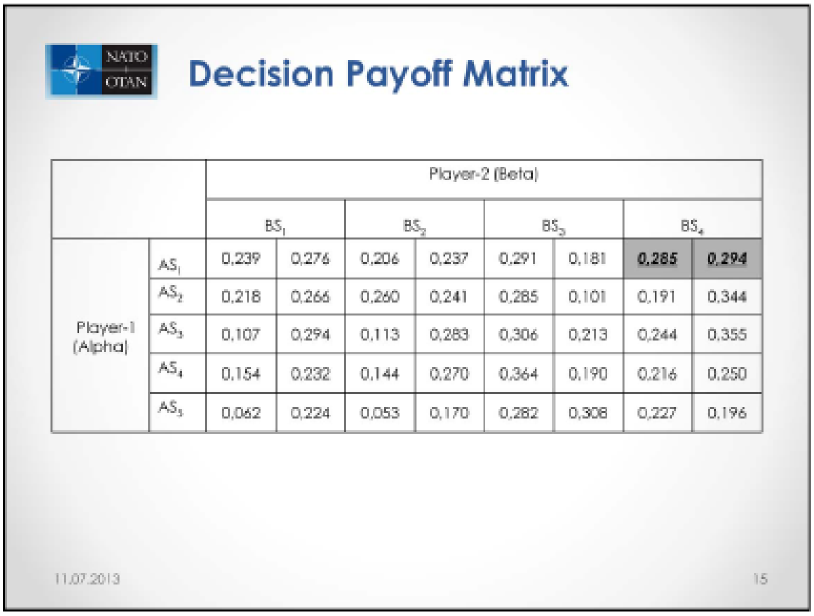
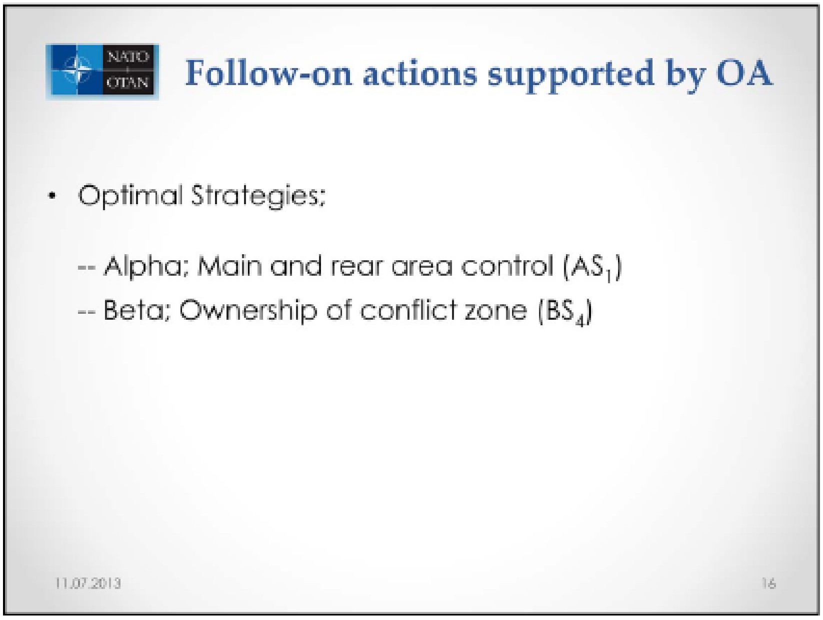
Fuzzy TOPSIS (Chen and Hwang, 1992) method is applied in this phase of methodology. This step is implemented in game theory perspective and strategies are compared with opposite player strategies reciprocally.

* Key criteria and linguistic variables are used for this comparison.
* This is an evaluation respect to each strategies of opposite player and closeness coefficients are calculated.
* These coefficients are used to present the power of each strategy respect to opposite players' one and a payoff matrix is formed.
* This payoff matrix shows the performance and satisfaction degree of strategies according to key criteria.



		Player-2 (Beta)							
		BS_1		BS_2		BS_3		BS_4	
Player-1 (Alpha)	AS_1	0.239	0.276	0.206	0.237	0.291	0.181	***0.285***	***0.294***
	AS_2	0.218	0.266	0.260	0.241	0.285	0.101	0.191	0.344
	AS_3	0.107	0.294	0.113	0.283	0.306	0.213	0.244	0.355
	AS_4	0.154	0.232	0.144	0.270	0.364	0.190	0.216	0.250
	AS_5	0.062	0.224	0.053	0.170	0.282	0.308	0.227	0.196

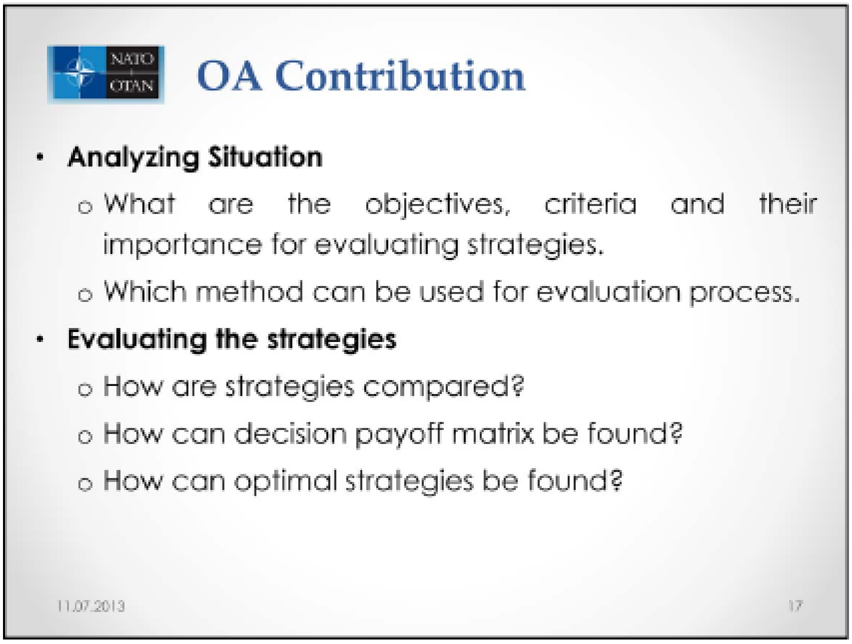
Finally, Decision Payoff matrix is found.
* The performance coefficients which are calculated for objectives and criteria, are combined with scalar multiplication and final coefficients are found for each case (Decision payoff matrix).
* As a final phase of solution, the equilibrium point is found for game. The optimal strategies are determined (AS1& BS4).



Optimal Strategies;

-- Alpha; Main and rear area control (AS_1)

-- Beta; Ownership of conflict zone (BS_4)



OA Contributions can be listed as;

Analyzing Situation

What are the objectives, criteria and their importance for evaluating strategies.

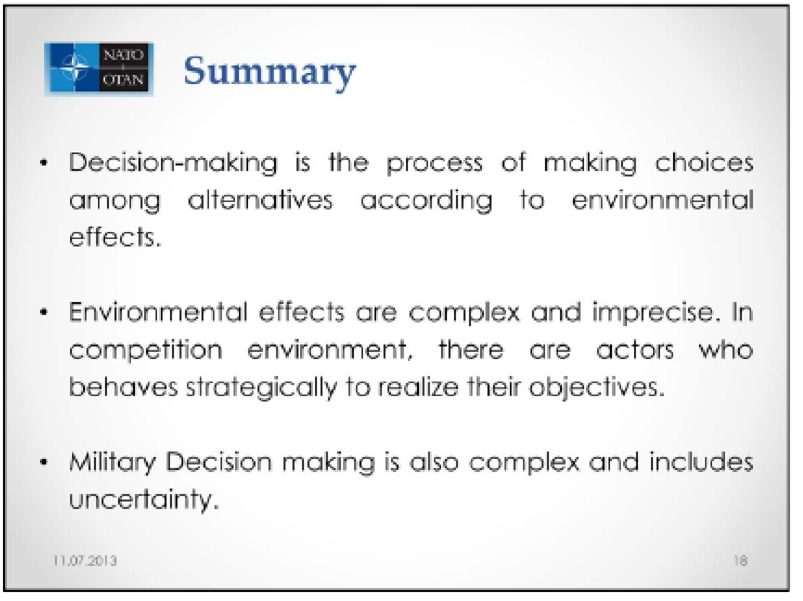
Which method can be used for evaluation process.

Evaluating the strategies

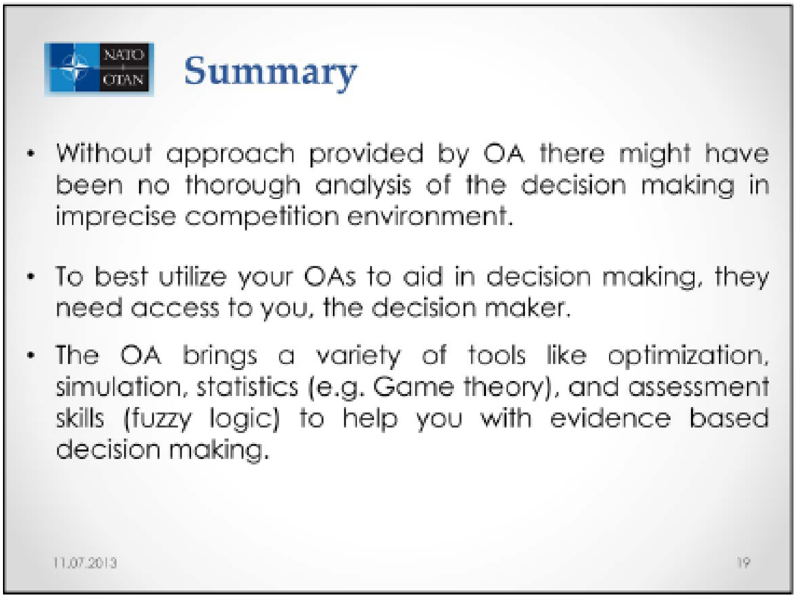
How are strategies compared?

How can decision payoff matrix be found?

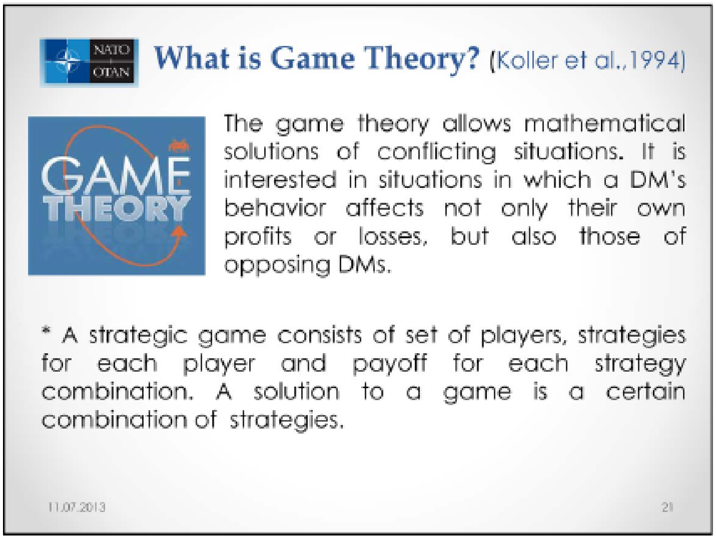
How can optimal strategies be found?



If it is summarized;
* Decision-making is the process of making choices among alternatives according to environmental effects.
* Environmental effects are complex and imprecise. In competition environment, there are actors who behaves strategically to realize their objectives.
* Military Decision making is also complex and includes uncertainty.



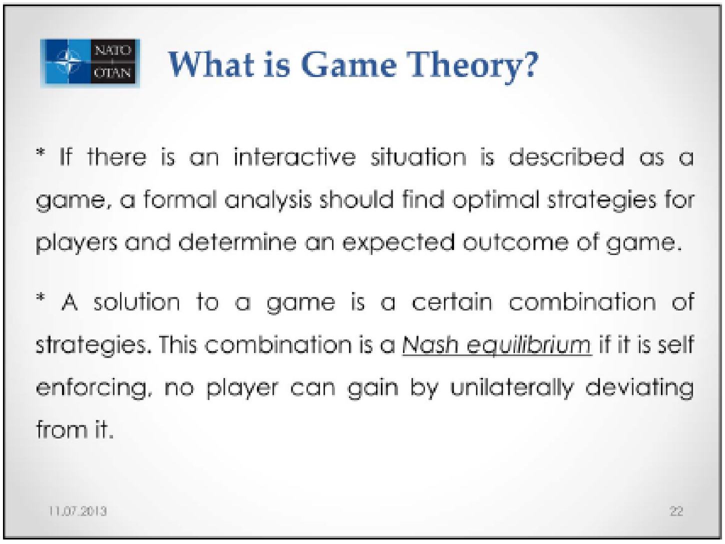
* Without approach provided by OA there might have been no thorough analysis of the decision making in imprecise competition environment.
* To best utilize your OAs to aid in decision making, they need access to you, the decision maker.
* The OA brings a variety of tools like optimization, simulation, statistics (e.g. Game theory), and assessment skills (fuzzy logic) to help you with evidence based decision making.



What is Game Theory (Koller et al.,1994);

* The game theory allows mathematical solutions of conflicting situations. It is interested in situations in which a Decision Maker's (DMs) behavior affects not only their own profits or losses, but also those of opposing DMs.

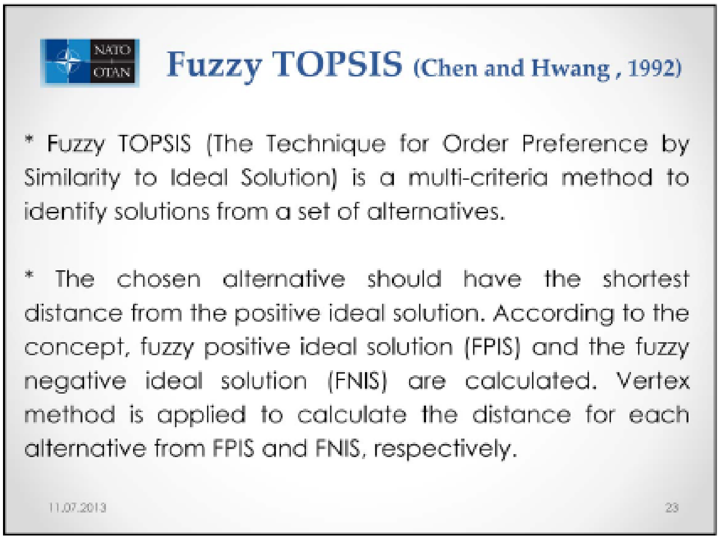
* A strategic game consists of set of players, strategies for each player and payoff for each strategy combination. A solution to a game is a certain combination of strategies.



What is Game Theory?

* If there is an interactive situation is described as a game, a formal analysis should find optimal strategies for players and determine an expected outcome of game.

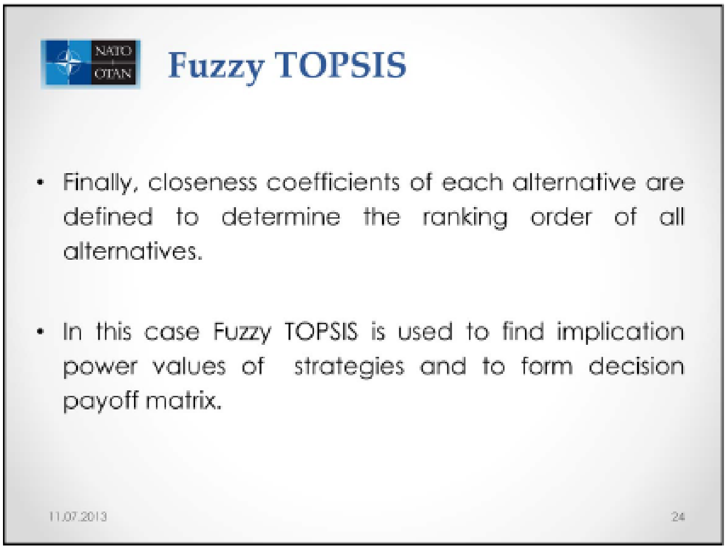
* A solution to a game is a certain combination of strategies. This combination is a *Nash equilibrium* if it is self enforcing, no player can gain by unilaterally deviating from it.



Fuzzy TOPSIS;

* Fuzzy TOPSIS (The Technique for Order Preference by Similarity to Ideal Solution) is a multi-criteria method to identify solutions from a set of alternatives.

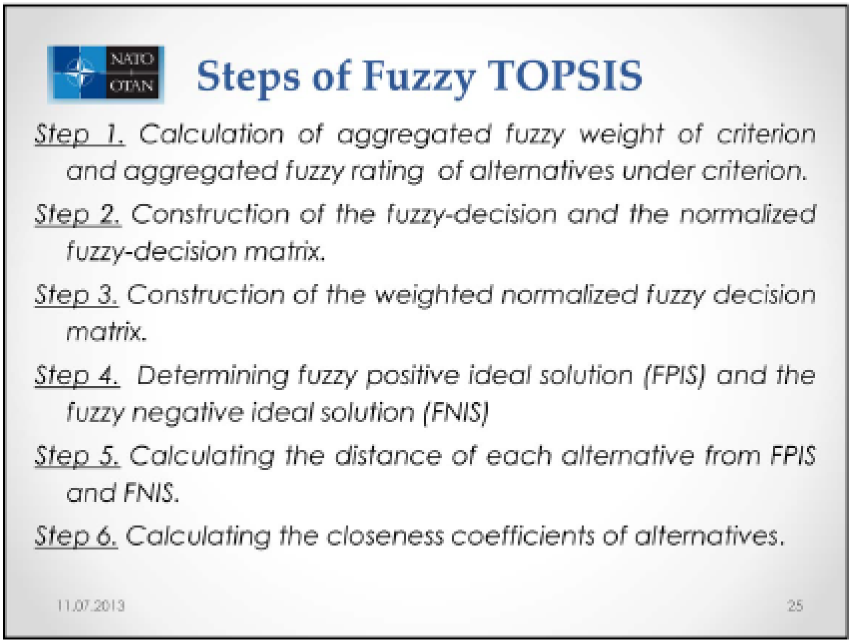
* The chosen alternative should have the shortest distance from the positive ideal solution. According to the concept, fuzzy positive ideal solution (FPIS) and the fuzzy negative ideal solution (FNIS) are calculated. Vertex method is applied to calculate the distance for each alternative from FPIS and FNIS, respectively.



Fuzzy TOPSIS ;

* Finally, closeness coefficients of each alternative are defined to determine the ranking order of all alternatives.

* In this case Fuzzy TOPSIS is used to find implication power values of strategies and to form decision payoff matrix.



Steps of Fuzzy TOPSIS are;

Step 1. Calculation of aggregated fuzzy weight of criterion and aggregated fuzzy rating of alternatives under criterion.

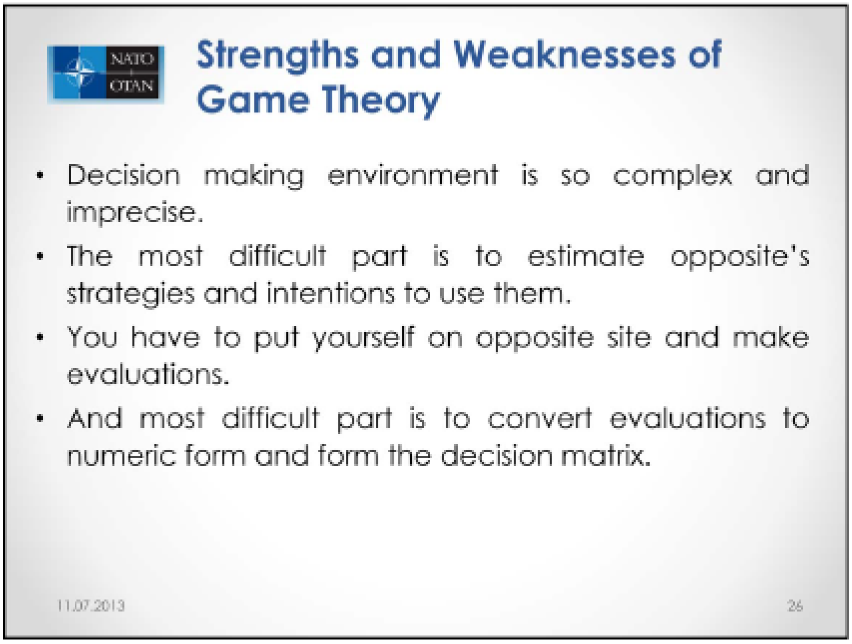
Step 2. Construction of the fuzzy-decision and the normalized fuzzy-decision matrix.

Step 3. Construction of the weighted normalized fuzzy decision matrix.

Step 4. Determining fuzzy positive ideal solution (FPIS) and the fuzzy negative ideal solution (FNIS)

Step 5. Calculating the distance of each alternative from FPIS and FNIS.

Step 6. Calculating the closeness coefficients of alternatives.



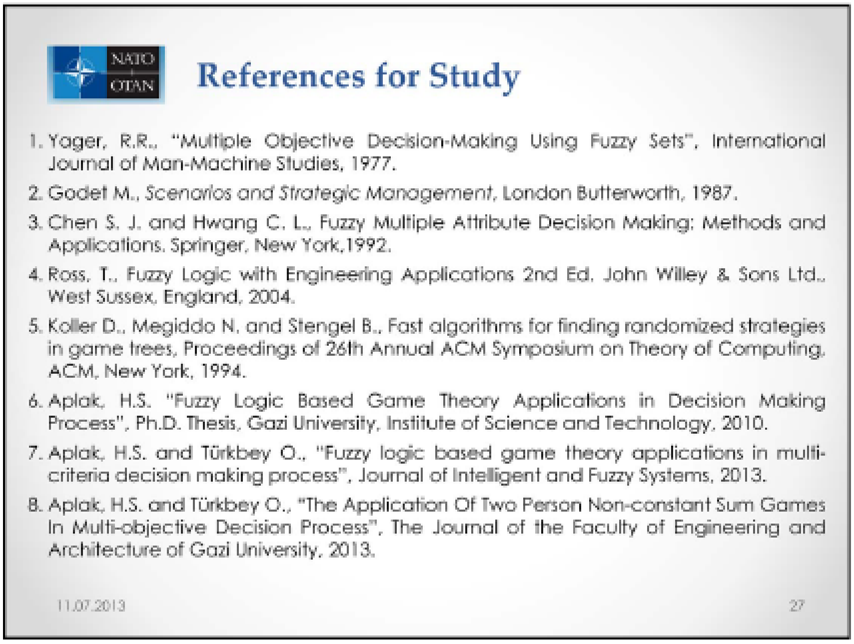
Strengths and Weaknesses of Game Theory;

* Decision making environment is so complex and imprecise.

* The most difficult part is to estimate opposite's strategies and intentions to use them.

* You have to put yourself on opposite site and make evaluations.

* And most difficult part is to convert evaluations to numeric form and form the decision matrix.



References for Study;

1. Yager, R.R., "Multiple Objective Decision-Making Using Fuzzy Sets", International Journal of Man-Machine Studies, 1977.
2. Godet M., *Scenarios and Strategic Management*, London Butterworth, 1987.
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5. Koller D., Megiddo N. and Stengel B., Fast algorithms for finding randomized strategies in game trees, Proceedings of 26th Annual ACM Symposium on Theory of Computing, ACM, New York, 1994.
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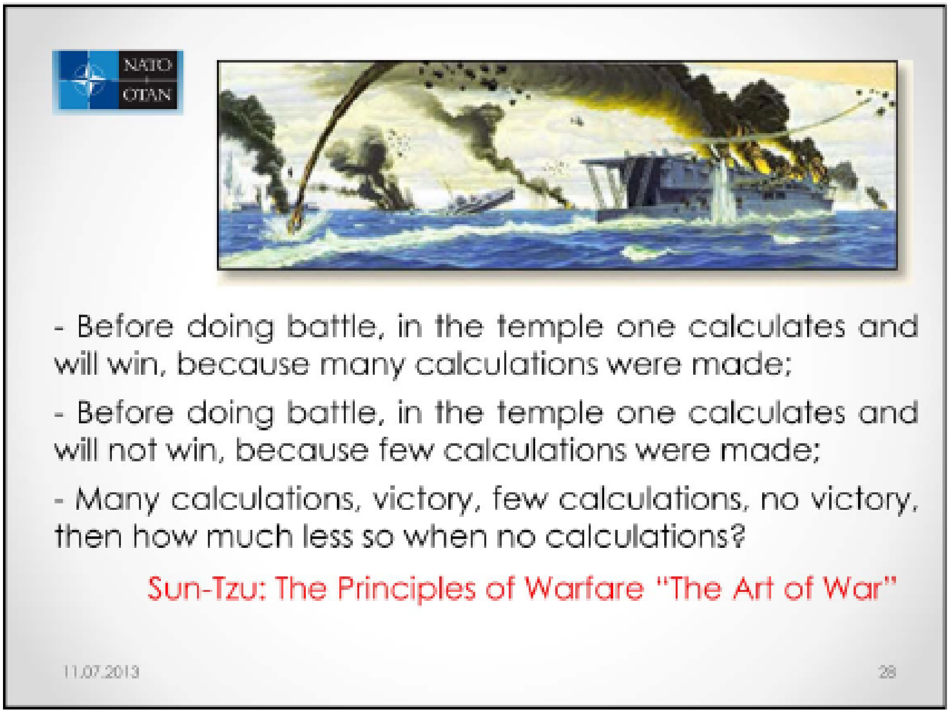
7. Aplak, H.S. and Türkbey O., "Fuzzy logic based game theory applications in multi-criteria decision making process", Journal of Intelligent and Fuzzy Systems, 2013.
8. Aplak, H.S. and Türkbey O., "The Application Of Two Person Non-constant Sum Games In Multi-objective Decision Process", The Journal of the Faculty of Engineering and Architecture of Gazi University, 2013.



- Before doing battle, in the temple one calculates and will win, because many calculations were made;

- Before doing battle, in the temple one calculates and will not win, because few calculations were made;

- Many calculations, victory, few calculations, no victory, then how much less so when no calculations?

Sun-Tzu: The Principles of Warfare "The Art of War"

A.2.5 Improving Situational Awareness through Patterns

INSTRUCTIONAL MODULE SUMMARY

Title	Correlation Analysis: Looking for Pattern and Relationships
Faculty Name(s)	Carsten Lauenroth, Bundeswehr Planning Office, Ottobrunn, DEU
Length	30 – 45 minutes
Learning Objectives	Understand the relationship between time series analysis and correlation analysis. Appreciate the difficulties of descriptive statistics. Appreciate smoothing, correlation analysis, and causality. Appreciate the strengths and weaknesses of quantitative assessment methods. Be able to "read" scatter plot charts.
Outcomes	As the result of this module, participants will be able to: Appreciate the diversity of data analysis and finding of relationships. Understand the shortcomings of different influences on time series analysis.
Content Outline	Case Study: Enemy Fighting Season in AFG. Time Series Analysis examples. Correlation Analysis examples. Usage of Ratio and Smoothing.
Materials	List Required Pre-Readings: ISAF Monthly Data: http://www.isaf.nato.int/article/news/monthly-trends.html.
Methods	90% Lecture 10% Class Exercises. _____% Break Outs.
Exercise(s)	Seminar participants will be asked to evaluate charts from the case study.
Break Outs	___ Yes X No. __#___ participants in each break out group.
Discussion Questions	In your experience, where is data analysis used most in your organization? How can the ability of time series analysis and finding patterns be taken into account while planning operations? How can we measure progress/success in a population centric COIN operation?

Improve Situational Awareness

A Case Study in Correlation Analysis

07.09.12 1

Overview

Situation: Afghanistan 2011, continuous assessment on enemy initiated attacks at HQ ISAF AAG in 2011.

Decision: Identify and clarify of enemy seasonal activities for Afghanistan, generally.

Objective: Enhance situational awareness in HQ ISAF.

OA Contribution: Time series analysis based on historical data and show of dependencies of various factors (Statistics).

Result: Model of the enemy fighting cycle

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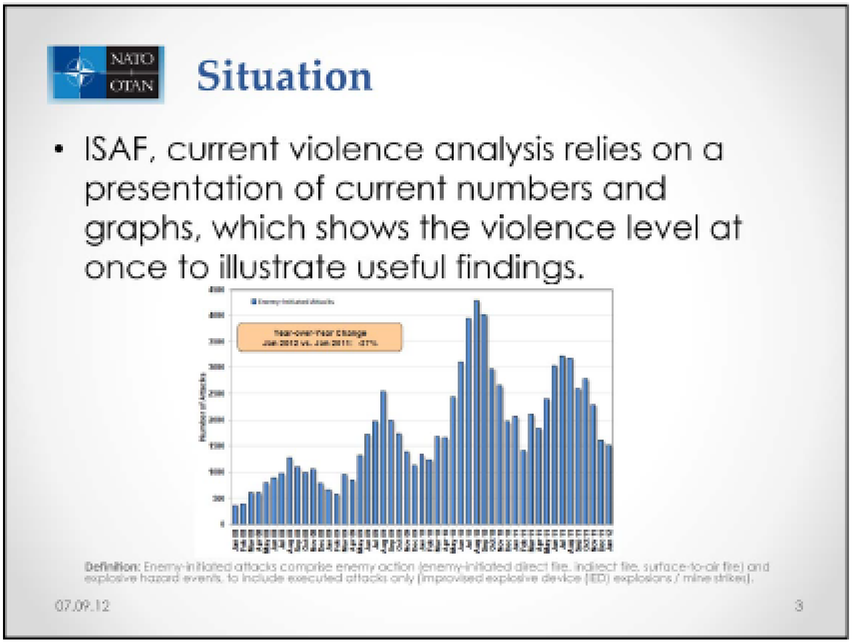


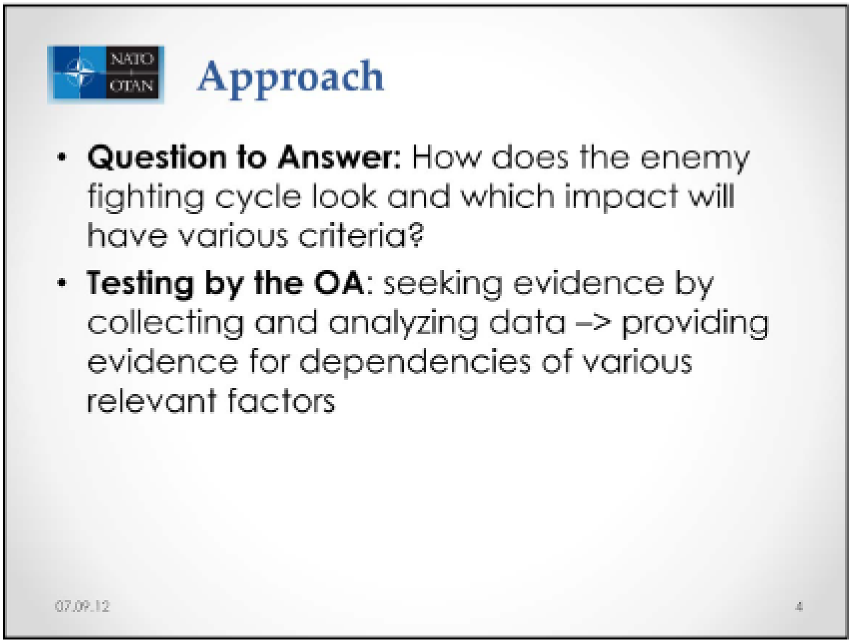
Slide 3:

Start with a Chart. This chart is part of the ISAF AAG monthly data release to the press.
The graph represents the nationwide enemy-initiated attacks since January 2008. AAG provides the Staff of HQ ISAF with violence analysis and data assessments. The current violence analysis relies on a presentation of current numbers and graphs, which shows the violence level at once to illustrate useful findings. Further on, these time series graphs include trends and seasonal variations. There are many factors that have to be taken into account; the strength of ISAF, the change of the seasons, the poppy cycle, and the enemy fighting season.

Based on historical data, the time series of enemy-initiated attacks shows strong seasonal rhythm with an increase of enemy-initiated attacks during the first half of the year and a decrease during the second half. However, which factors are influencing this pattern and is it possible to identify the insurgent fighting season?

Definition: Enemy-initiated attacks comprise enemy action (enemy-initiated direct fire, indirect fire, surface-to-air fire) and explosive hazard events, to include executed attacks only (improvised explosive device (IED) explosions / mine strikes).

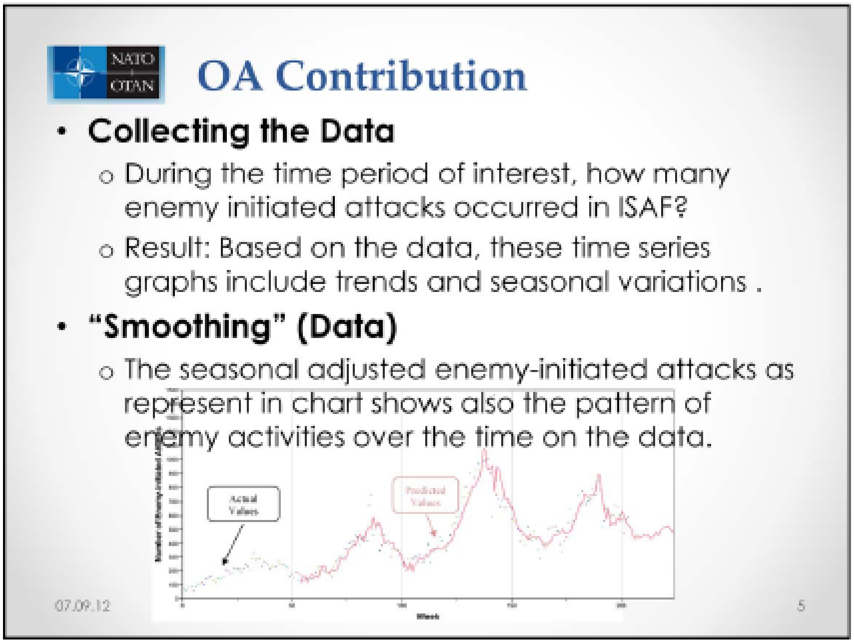
Data Source: Afghan Mission Network (AMN) Combined Information Data Network Exchange (CIDNE) Database, as of 16 Feb 2012.



Slide 4:
Relevant factors are:

- ISAF Troop strength?
- Temperature?
  - Rainfall
  - Snow level?
- Poppy cultivation?
- Religious Dates?

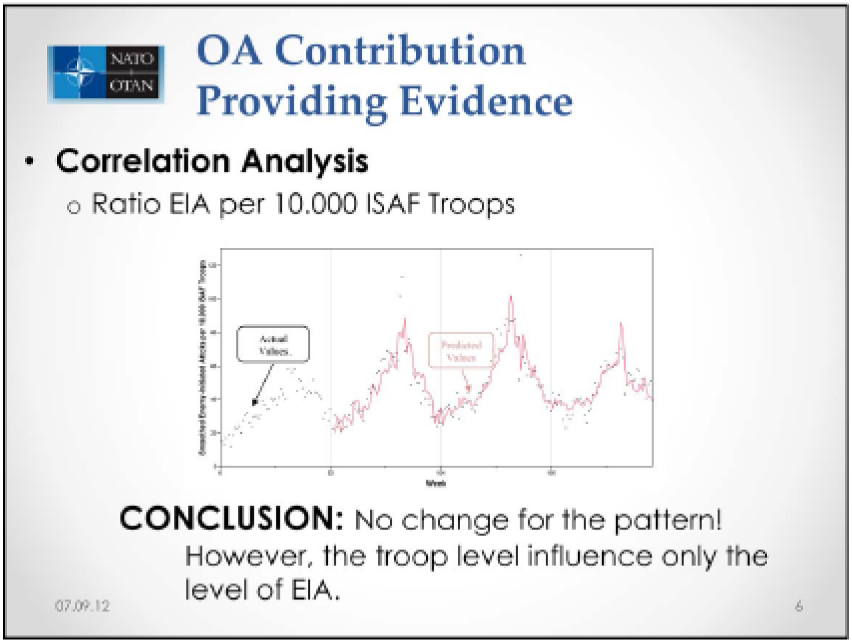
Factors that could have some influence on the enemy fighting rhythm are weather conditions, like temperature, rainfall and snowfall; religious dates, like Ramadan, Eid al Fitr, and Eid al Adha; special events or announcements, like Mullah Omar's Al Badr announcement or elections; the poppy cycle; and the ISAF Troop level.



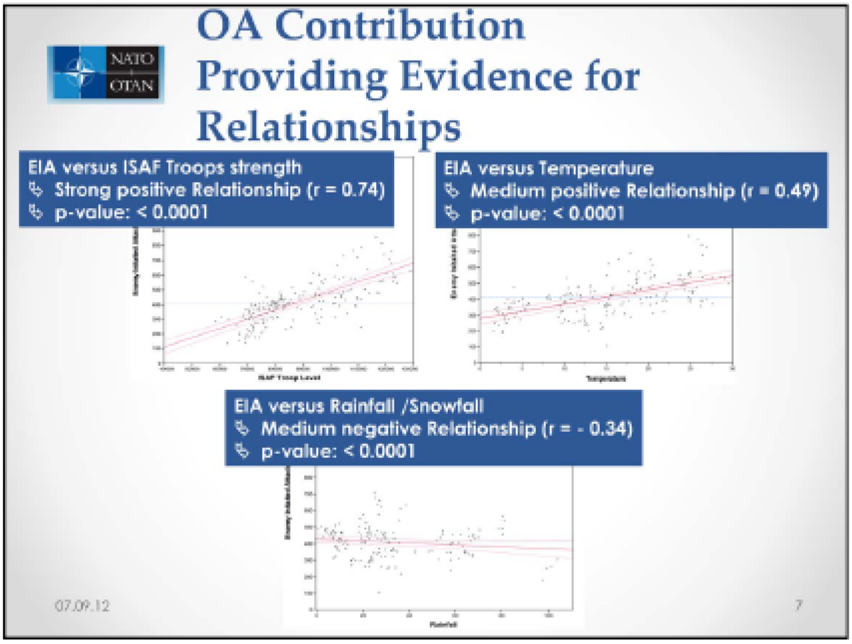
Slide 5:

The seasonal adjusted enemy-initiated attacks as represent in upper chart shows also the pattern of enemy activities over the time. Further on, the graph shows the increase of enemy-initiated attacks from 2008 to 2010 and a decrease form 2010 to 2011. However, independent of the level of enemy-initiated attacks the rhythm for each year seems to be similar.

ARIMA models are the most general class of models for forecasting a time series. In fact, the easiest way to think of ARIMA models is as fine-tune versions of random-walk and random-trend models. The acronym ARIMA stands for "Auto-Regressive Integrated Moving Average". In this case we used SARIMA (1, 1, 2) (1, 1, 2) 52 by JMP, a mixed model (exponential smoothing and autoregressive Model which includes seasonality).



Slide 6:
ARIMA models are the most general class of models for forecasting a time series. In fact, the easiest way to think of ARIMA models is as fine-tune versions of random-walk and random-trend models. The acronym ARIMA stands for "Auto-Regressive Integrated Moving Average". In this case we used SARIMA (1, 1, 2) (1, 1, 2) 52 by JMP, a mixed model (exponential smoothing and autoregressive Model which includes seasonality).

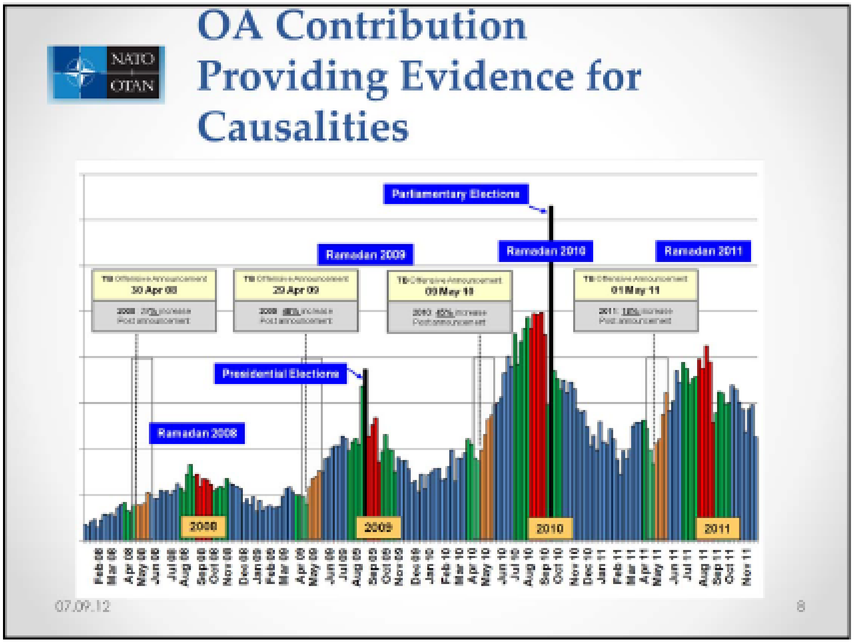


Slide 7 (Correlation Analysis (Scatter Plot)):

The relationship between the ISAF Troop level and the number of enemy-initiated attacks (upper left chart) shows a strong, positive correlation between these two factors; the correlation coefficient is 0.74 with p-value lower than 0.0001. That means this result is statistically significant.

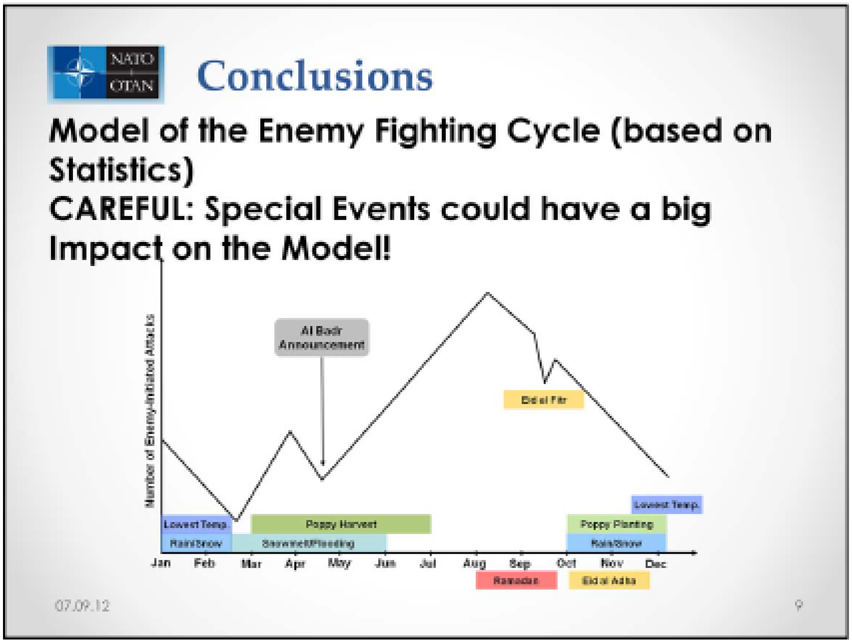
The relation between the number of enemy-initiated attacks and the temperature is depicted in the upper right chart. This chart shows the medium, positive correlation between these two factors, for which the correlation coefficient is 0.49 with p-value lower than 0.0001. That means; if the temperature is increasing than the number of enemy-initiated attacks normally increases and this is statistically significant.

Additionally, the relationship between the number of enemy-initiated attacks and the rainfall level is shown in Figure 8. This figure shows a weak, negative correlation between these two factors; the correlation coefficient is -0.34 with p-value lower than 0.0001[Regarding the normal quantile plot, the numbers enemy-initiated attacks are normal distributed within a 90 percent confidence interval]. That means; if the rainfall level is decreasing than usually the number of enemy-initiated attacks increases and this is statistically significant.



Slide 8:

In common usage, **causality** is also the relationship between a set of factors (causes) and a phenomenon (the *effect*). Anything that affects an effect is a factor of that effect. A direct factor is a factor that affects an effect directly, that is, without any intervening factors. (Intervening factors are sometimes called "intermediate factors.").



Slide 9:
Conclusions.
The insurgent fighting cycle follows seasonal pattern!
This fighting cycle depends on various factors like the temperature, rainfall, religious dates, and the poppy cycle. Based on historical data, the insurgent fighting cycle shows typically peaked during the month of August with violence levels tapering by September. The cycle starts with the “Al-Badr” campaign in early May and increase until August, usually until begin of the Ramadan Period, and decrease up to February. That will only be interrupted for a short increasing period after the “Eid-Al Fitr” holydays at the end of the Ramadan. The insurgent attacks reach there lowest level in the middle of February. During March and early April is a short increase or insurgent attacks observed, especially in RC South, Southwest, and West, the main areas for poppy cultivation in Afghanistan. The climatology has an impact on insurgent activities. We also had shown that the ISAF Troop level has an impact on the number of enemy-initiated attacks. However, the ISAf Troop level does not influence the insurgent fighting cycle, generally.


Used OA Tools
Microsoft Excel:
• Commercial Spreadsheet Application
• Strengths:
• Standard Software
• Calculation, Graphing Tools, Pivot Tables, and Macro Programming (VBA)
• Weakness:
• Accuracy and Convenience of Statistical Tools (handling of round-off and large numbers)
07.09.12
10


Used OA Tools
jmp
JMP:
• Commercial Application to Perform Simple and Complex Statistical Analysis
• Strengths:
• Statistical Software
• Weakness:
• No Standard Software
• Needs Training
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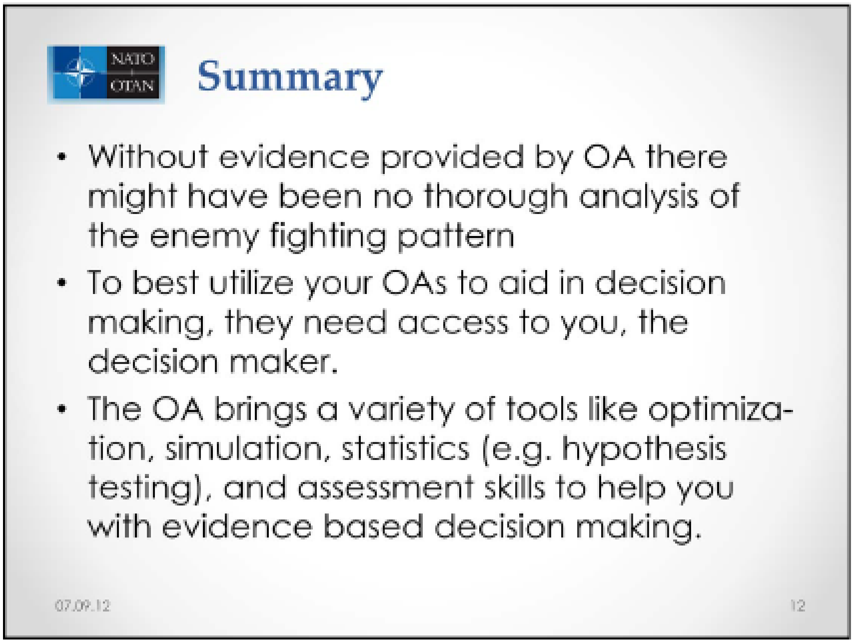
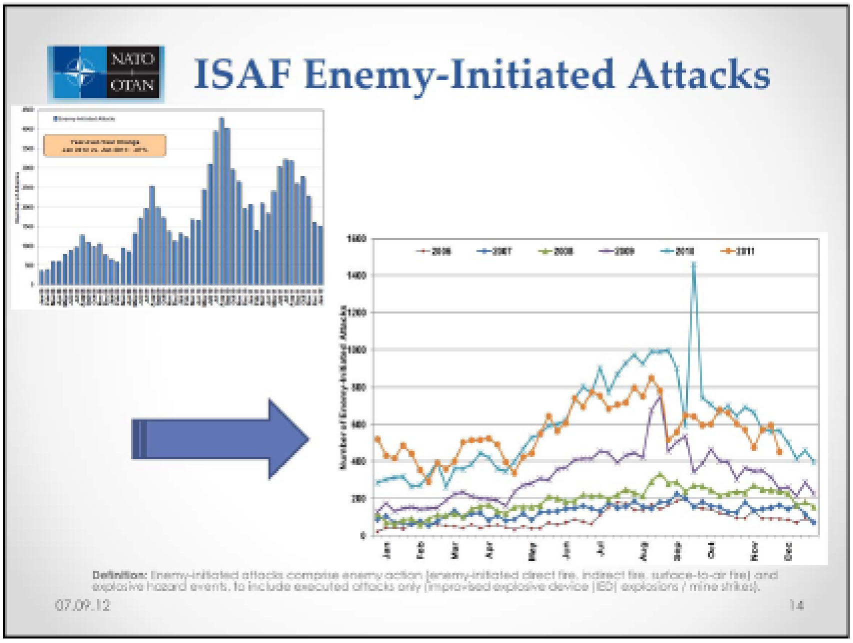
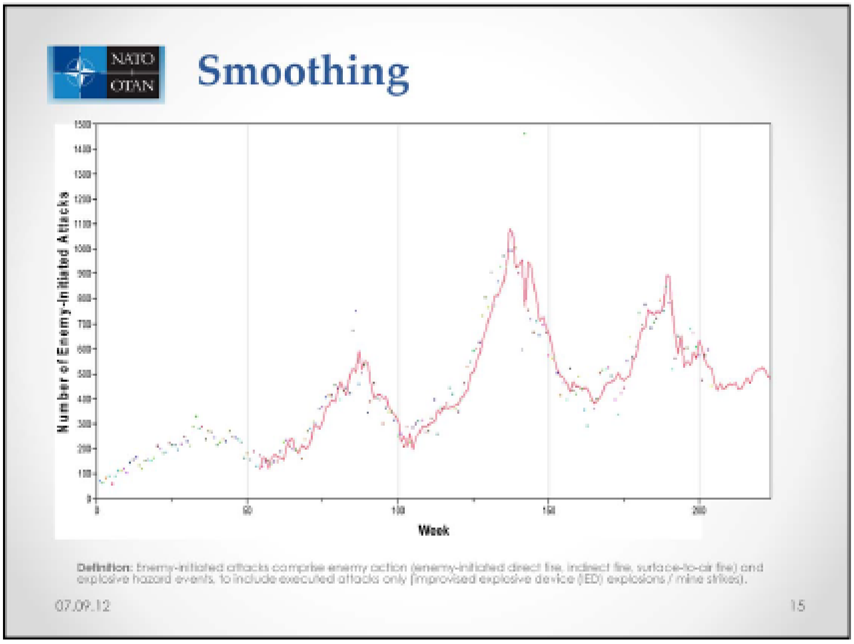




Slide 14:

Definition: Enemy-initiated attacks comprise enemy action (enemy-initiated direct fire, indirect fire, surface-to-air fire) and explosive hazard events, to include executed attacks only (improvised explosive device (IED) explosions / mine strikes).

Data Source: Afghan Mission Network (AMN) Combined Information Data Network Exchange (CIDNE) Database, as of 16 Feb 2012.



Slide 15:

ARIMA models are the most general class of models for forecasting a time series. In fact, the easiest way to think of ARIMA models is as fine-tune versions of random-walk and random-trend models. The acronym ARIMA stands for "Auto-Regressive Integrated Moving Average". In this case we used SARIMA (1, 1, 2) (1, 1, 2) 52 by JMP, a mixed model (exponential smoothing and autoregressive Model which includes seasonality).

Definition: Enemy-initiated attacks comprise enemy action (enemy-initiated direct fire, indirect fire, surface-to-air fire) and explosive hazard events, to include executed attacks only (improvised explosive device (IED) explosions / mine strikes).

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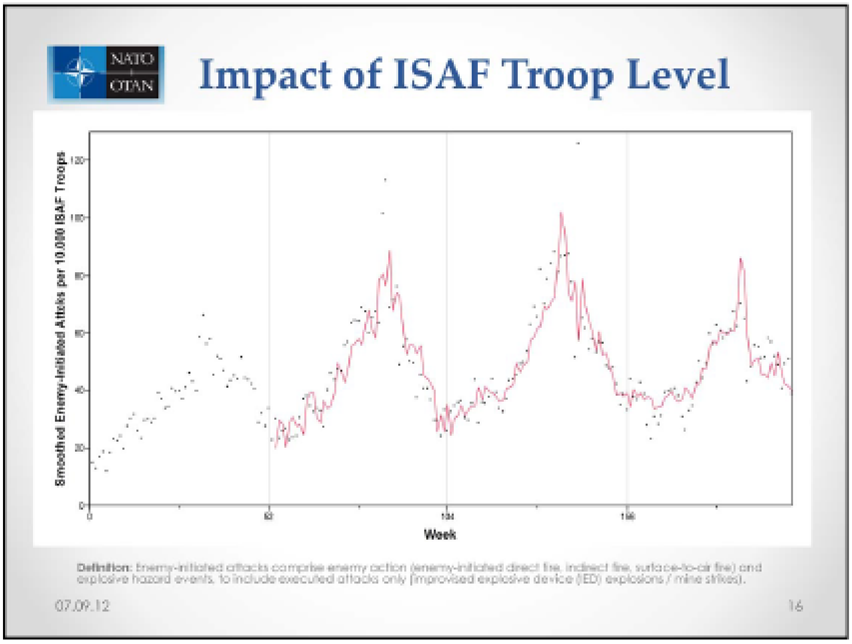

Slide 16:

As shown on the slide before; over the last 4 years the seasonal pattern has remained unchanged, as only the level of enemy-initiated attacks increased. For that reason, we computed the ratio of enemy-initiated attacks per 10,000 ISAF troops (depicted on this slide). This graph shows the same pattern of enemy activity over the last 4 years. Given this, we can assess there is no impact on the fighting season pattern of the insurgent. The ISAF troop level has only an influence on the level of violence.

ARIMA models are the most general class of models for forecasting a time series. In fact, the easiest way to think of ARIMA models is as fine-tune versions of random-walk and random-trend models. The acronym ARIMA stands for "Auto-Regressive Integrated Moving Average". In this case we used SARIMA (1, 1, 2) (1, 1, 2) 52 by JMP, a mixed model (exponential smoothing and autoregressive Model which includes seasonality).

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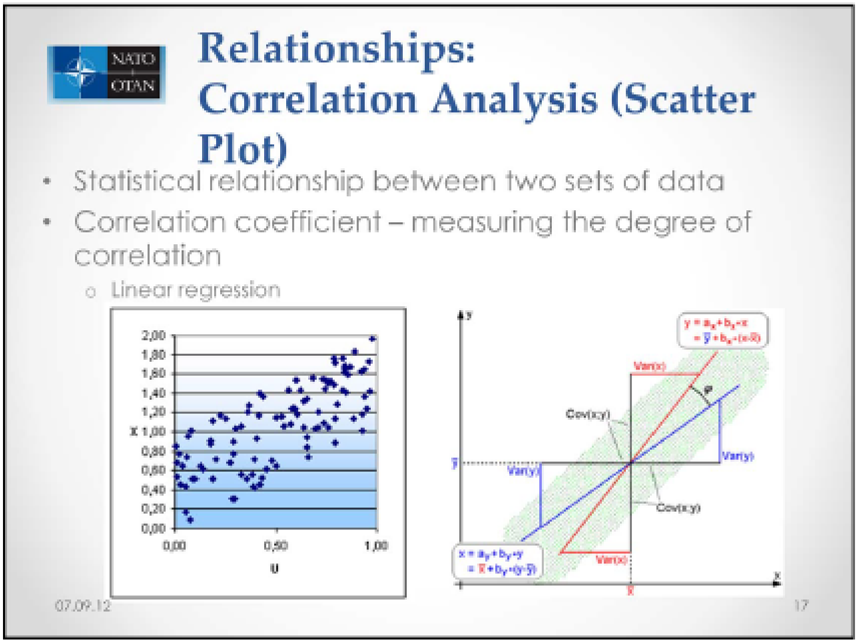
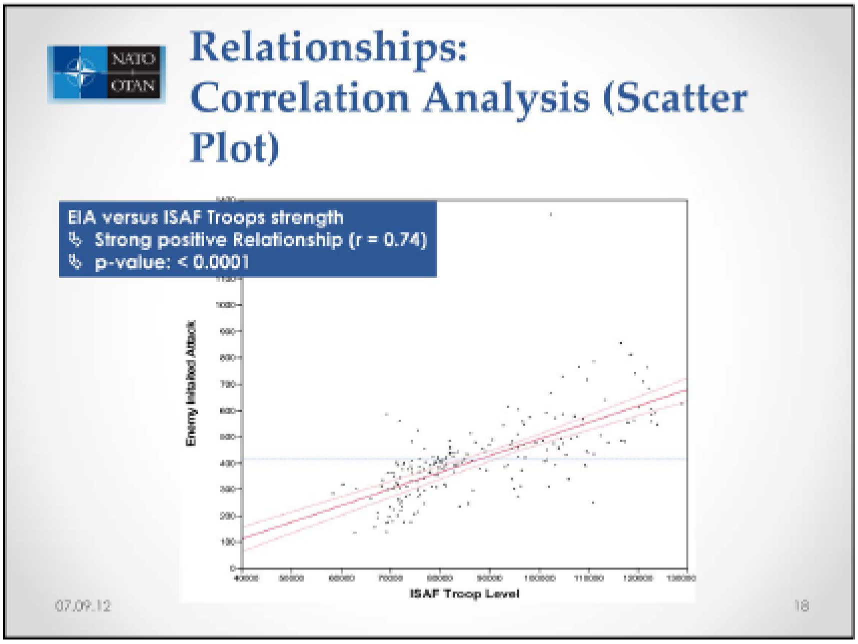


Slide 17:

Short introduction of Correlation Analysis and Scatter Plots.
Correlation Analysis:
In statistics, **dependence** refers to any statistical relationship between two sets of data. **Correlation** refers to any of a broad class of statistical relationships involving dependence. There are several **correlation coefficients**, often denoted ρ or r, measuring the degree of correlation. The most common of these is the Pearson correlation coefficient, which is sensitive only to a linear relationship between two variables.
In the case of the bivariate normal distribution the population Pearson correlation coefficient characterizes the joint distribution as long as the marginal means and variances are known. For most other bivariate distributions this is not true. Nevertheless, the correlation coefficient is highly informative about the degree of linear dependence between two random quantities regardless of whether their joint distribution is normal.
The result is statistically significant.
[In statistical significance testing, the **p-value** is the probability of obtaining a test statistic at least as extreme as the one that was actually observed, assuming that the null hypothesis is true. One often "rejects the null hypothesis" when the p-value is less than the significance level α (Greek alpha), which is often 0.05 or 0.01. When the null hypothesis is rejected, the result is said to be statistically significant.]

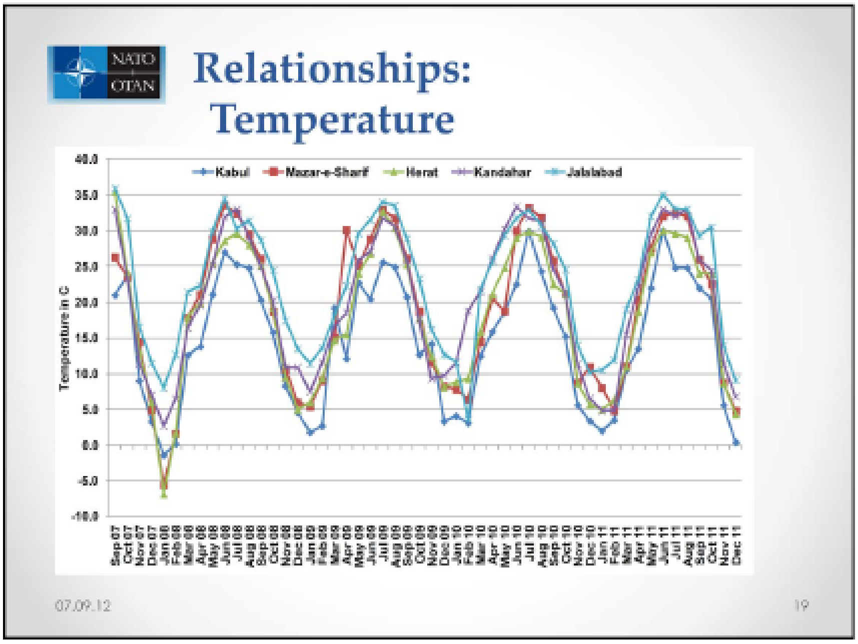
For uncentered data, the correlation coefficient corresponds with the cosine of the angle between both possible regression lines y=gx(x) and x=gy(y).



Slide 18:

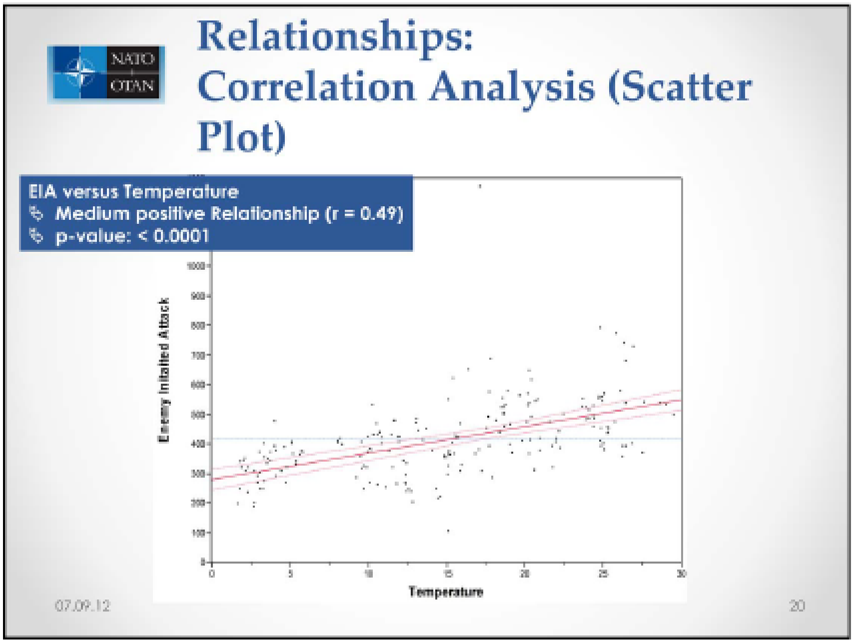
During the last couple of years, ISAF troop levels rose to approximately 120,000 troops. Due to the increasing ISAF operations tempo the number of enemy-initiated attacks increased significant over that same time. However, has the ISAF troop level had an effect on the enemy fighting cycle?

The relationship between the ISAF Troop level and the number of enemy-initiated attacks shows a strong, positive correlation between these two factors; the correlation coefficient is 0.74 with p-value lower than 0.0001. That means this result is statistically significant.



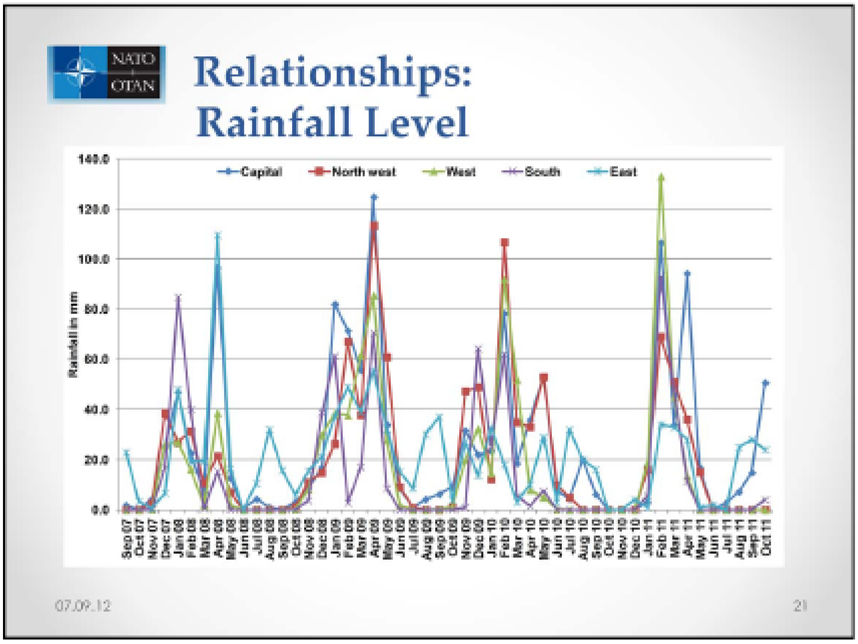
Slide 19:

Afghanistan has an arid, semi-arid to sub-humid climate with high inter-annual variation of precipitation. The chart shows the recorded temperature for five different regions of Afghanistan since September 2007. The temperature typically starts decreasing in September and drops to freezing in December in the Central Highlands and north-eastern parts and continues to decline until February. Generally, January is the coldest month of the year. The temperatures increase in March and reach maximums in July and August.



Slide 20:

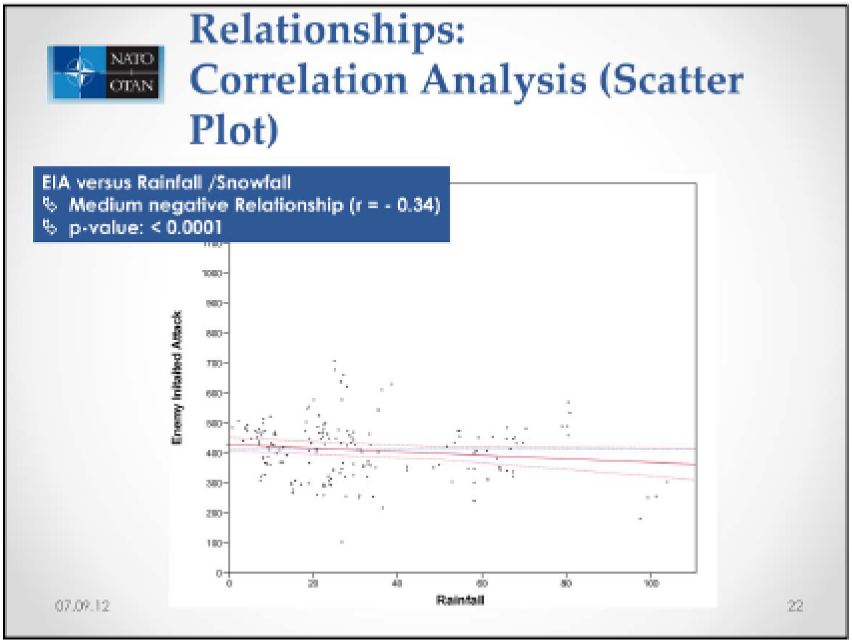
The relation between the number of enemy-initiated attacks and the temperature is depicted in the chart. This chart shows the medium, positive correlation between these two factors, for which the correlation coefficient is 0.49 with p-value lower than 0.0001. That means; if the temperature is increasing than the number of enemy-initiated attacks normally increases and this is statistically significant.



Slide 21:

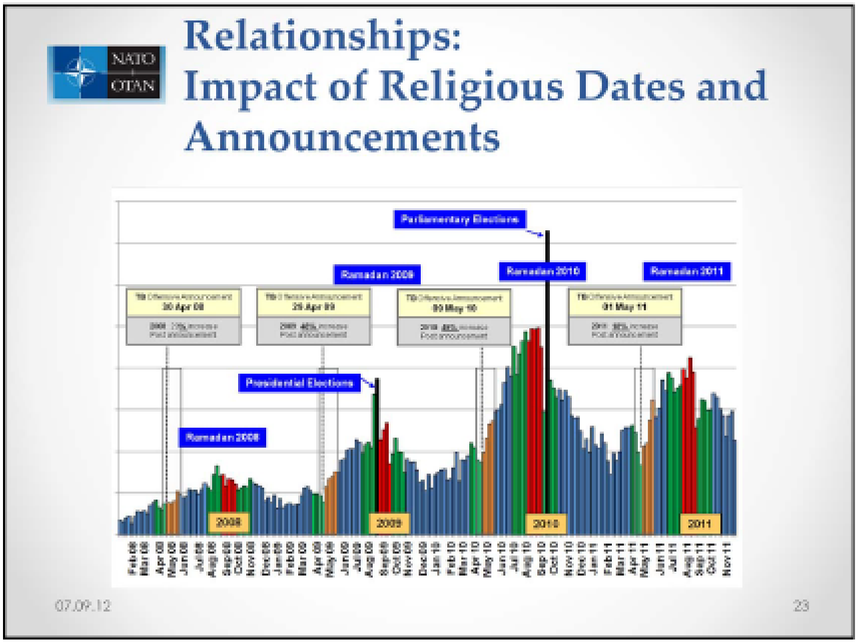
Spatial distribution of rainfall is variable in different regions of the country. During the rainy season the most amount of rainfall occurred in the Eastern region, and the north-eastern, northern, north-western, capital and eastern parts of the Central Highlands experienced moderate rainfall. The southern, south-western and western regions usually receive low amounts of rainfall.

At the beginning of the rainy season snow starts in some parts of the country. During October, snow pack develops in most parts of the country, particularly in the Central Highlands and north-eastern region, during December and mid-January snow is light and early January snow increases in most parts.



Slide 22:

Additionally, the relationship between the number of enemy-initiated attacks and the rainfall level is shown in Figure 8. This figure shows a weak, negative correlation between these two factors; the correlation coefficient is -0.34 with p-value lower than 0.0001[Regarding the normal quantile plot, the numbers enemy-initiated attacks are normal distributed within a 90 percent confidence interval]. That means; if the rainfall level is decreasing than usually the number of enemy-initiated attacks increases and this is statistically significant.

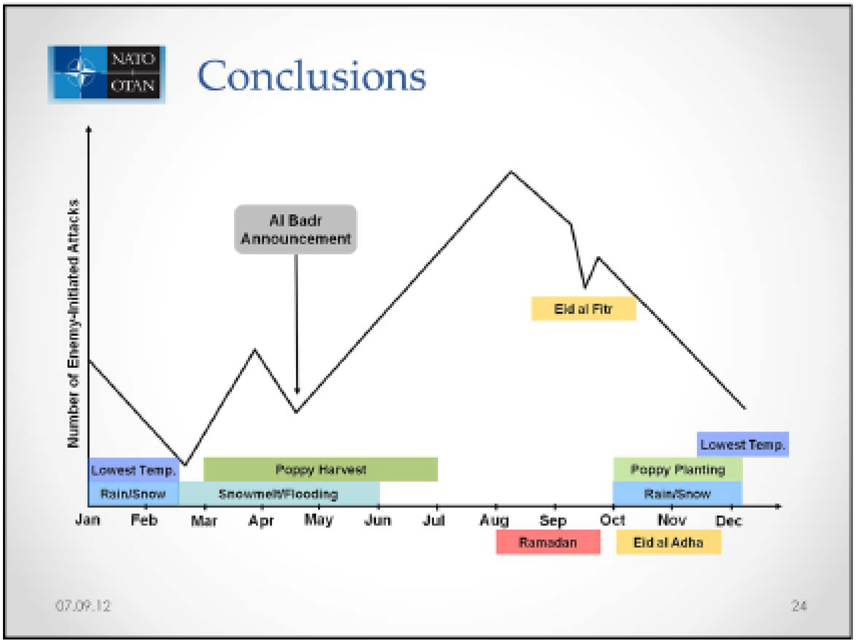


Slide 23:

Ramadan is the holy ninth month of the Islamic calendar occurring 10-11 days earlier each successive year on the Gregorian calendar. In 2008, Ramadan began on 01 September and ended on 30 September; in 2009, Ramadan began on 21 August and ended on 19 September; in 2010, Ramadan fell between 11 August and 09 September. In 2011, this month-long religious observance fell between 01 and 29 August, according to official dates set by religious leaders in Saudi Arabia.

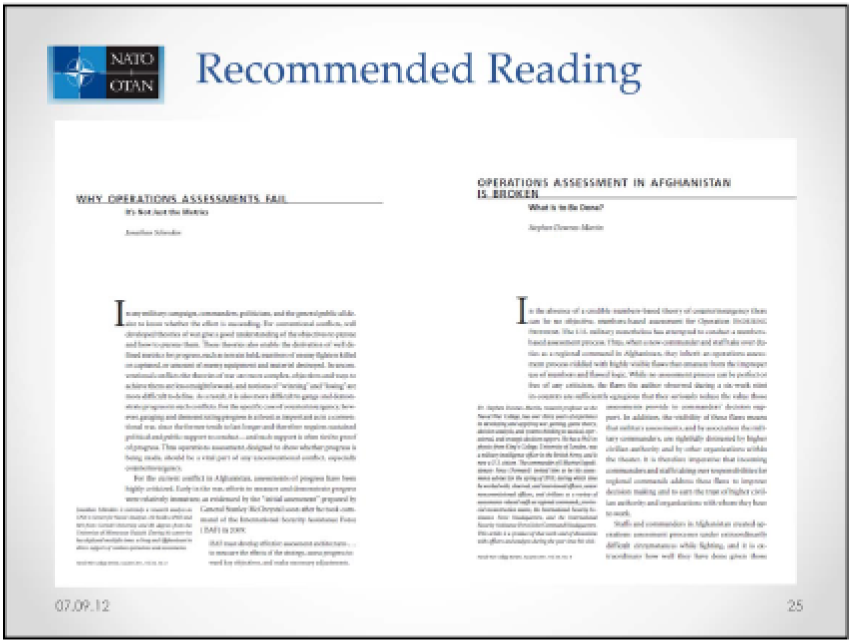
In 2008, there was an average of 36 enemy-initiated attacks per day during Ramadan, compared to an average of 42 attacks per day in the 30 days prior to Ramadan, a 14% decrease consistent with the seasonal decline. In 2009, attack levels during Ramadan decreased 16% from the 30 days prior. Similarly, enemy-initiated attacks in 2010 did not show any significant change in levels of insurgent attacks during Ramadan. However, Ramadan fell in the pre-election period of the Parliamentary Elections on 18 September 2010. Also, 2011 did not show any significant change in the level of attacks (shown on this slide).

The chart also shows bands corresponding to the “al-Badr” announcements and the first period of the Taliban campaign from 2008 through 2011. In 2009 and 2010, enemy-initiated attacks increased by approximately 45 percent in the four weeks following the announcement of the Taliban offensive. In 2011, enemy-initiated attacks increased only by 18 percent due to the warm winter conditions where the level of insurgent attack was higher than the years before.



Slide 24:

Conclusions:
The insurgent fighting cycle follows seasonal pattern. This fighting cycle depends on various factors like the temperature, rainfall, religious dates, and the poppy cycle. Based on historical data, the insurgent fighting cycle has typically peaked during the month of August with violence levels tapering by September. The cycle starts with the "al-Badr" campaign in early May and increase until August, usually until begin of the Ramadan period, and decrease up to February. That will only be interrupted for a short increasing period after the Eid-al Fitr holydays at this end of Ramadan. The insurgent attacks reach there lowest level in the middle of February. During March and early April is a short increase of insurgent attacks observed, especially in RC South, Southwest and West, the main areas for poppy cultivation in Afghanistan. This paper shows that several factors have more or less influence on the insurgent fighting behaviour. So has the climatology an impact on the insurgent activities. We also had shown that the ISAF troop level has an impact on the number of enemy-initiated attacks. However, the troop level does not influence the insurgent fighting pattern, generally.



Slide 25:

Recommended readings:

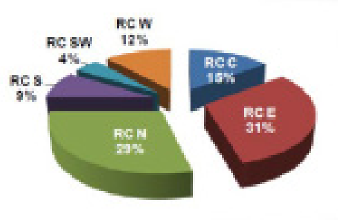
- Why operations assessments fail (Dr. Jonathan Schroden, CNA)
- Operations Assessment in Afghanistan is broken (Dr. Stephen Downes-Martin, NWC)

A.2.6 Improving Situational Awareness through Descriptive Statistics

INSTRUCTIONAL MODULE SUMMARY

Title	Descriptive Statistics: Hotspot Analysis and Geospatial Findings
Faculty Name(s)	Carsten Lauenroth, Bundeswehr Planning Office, Ottobrunn, DEU
Length	30 – 45 minutes
Learning Objectives	Understand the relationship between time series analysis and geospatial analysis. Appreciate the difficulties of using descriptive statistics. Appreciate the strengths and weaknesses in using ratios. Appreciate survey data and geospatial methods. Be able to “read” box plots.
Outcomes	As the result of this module, participants will be able to: Appreciate the diversity of ratio analysis and geospatial methods. Understand the shortcomings of different constraints on data visualization and time series analysis.
Content Outline	Case Study: Violence Trend on Province Level in AFG. Box Plot examples. Geospatial Analysis approach. Usage of Survey Data.
Materials	List Required Pre-Readings: ISAF Monthly Data: http://www.isaf.nato.int/article/news/monthly-trends.html.
Methods	90% Lecture 10% Class Exercises. _____% Break Outs.
Exercise(s)	Seminar participants will be asked to evaluate box plots from the case study.
Break Outs	___ Yes X No. __#___ participants in each break out group.
Discussion Questions	In your experience, where is descriptive statistics used most in your organization? How can the outcomes of a trend analysis taken into account during planning operations? How can we measure progress/success in a population centric COIN operation?

Improve Situational Awareness



A Case Study in Descriptive Statistics

11.09.12 1

Overview

Situation: Afghanistan 2011, continuous assessment on enemy initiated attacks at HQ ISAF AAG in 2011. Permanent task by COM ISAF.

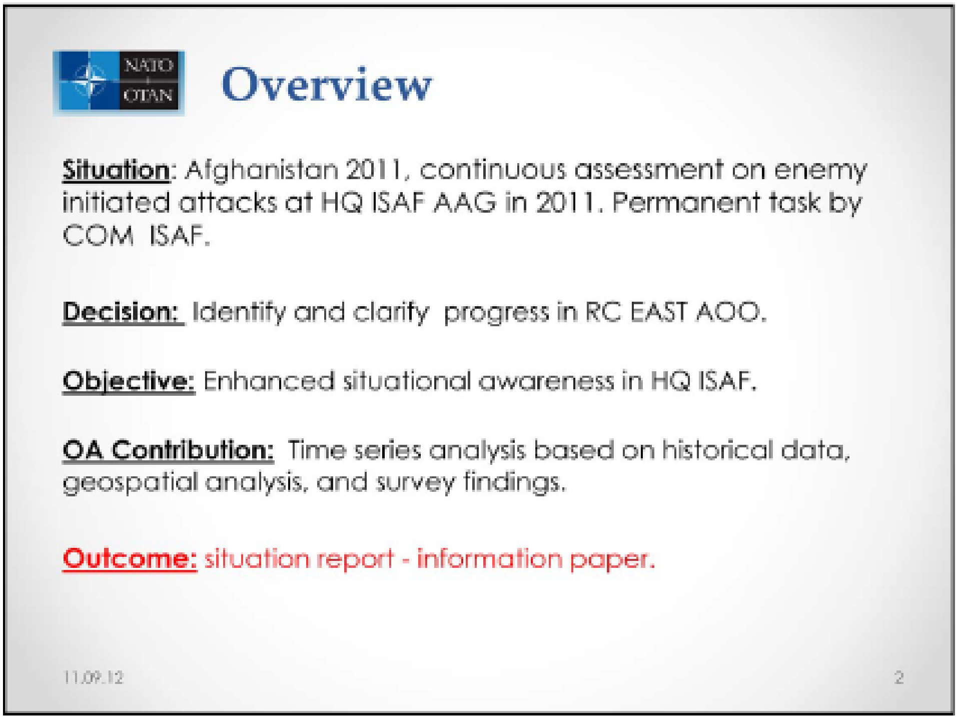
Decision: Identify and clarify progress in RC EAST AOO.

Objective: Enhanced situational awareness in HQ ISAF.

OA Contribution: Time series analysis based on historical data, geospatial analysis, and survey findings.

Outcome: situation report - information paper.

11.09.12 2


NATO OTAN
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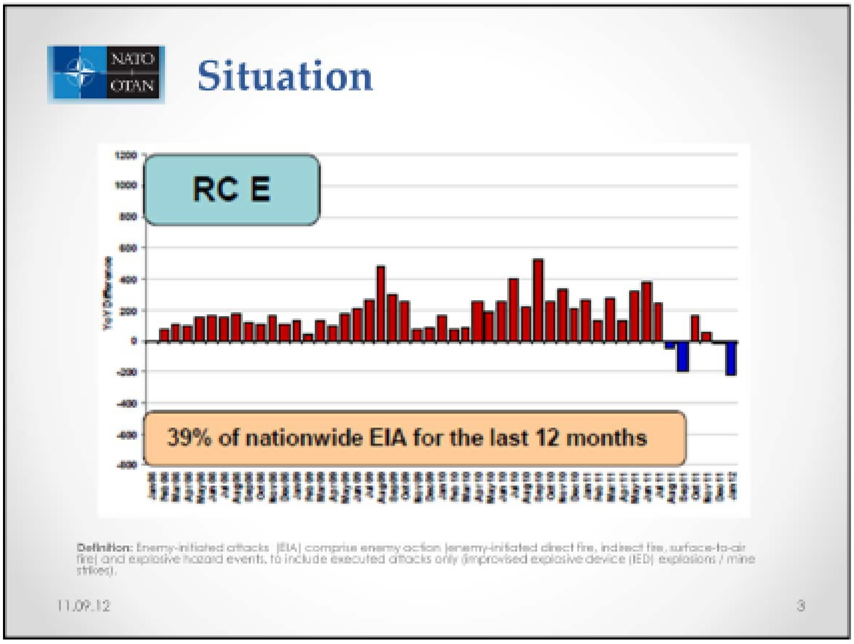
11.09.12
2

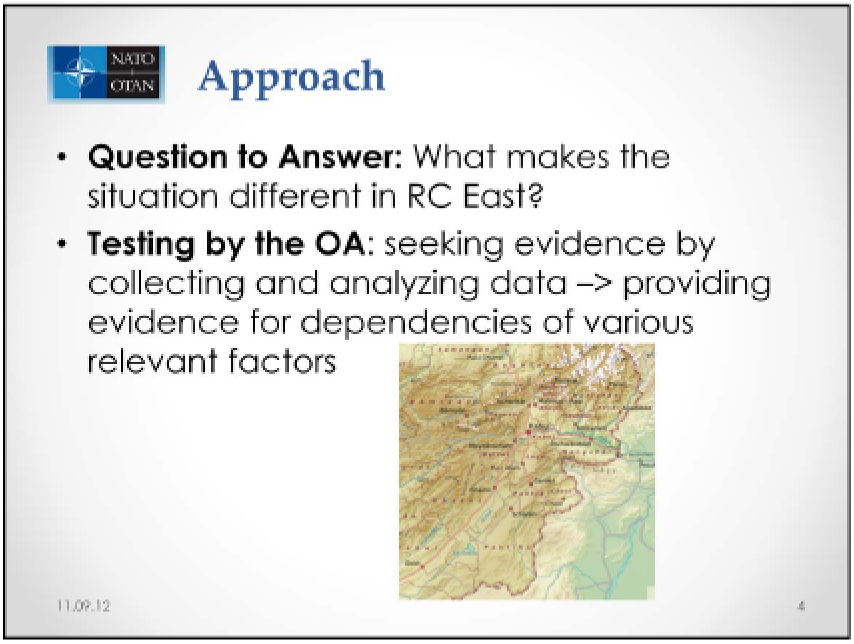


Slide 3:

Start with a Chart. This chart is part of the ISAF AAG monthly data release to the press.
The graph represents the year over year change of enemy-initiated attacks in RC East since January 2007. In addition, the charts shows that 39 percent of the nationwide EIA are happened in RC East during a period of 12 month.
AAG provides the Staff of HQ ISAF with violence analysis and data assessments. Recent Combined Team and Coalition Force successes in the southern portions of Afghanistan have led to a steady and progressive decrease in levels of significant activity (SIGACTs) and violence. However, the situation in RC east is different. The differences are not only the increasing of security incidents, also in particular the terrain and the kinds of attacks are different. Friendly forces movements are only possible along the small valleys, the mountainous area offer the insurgents various hiding-places. Further on, the far eastern part of the region is one of the poorest areas of Afghanistan due to a lack of infrastructure. Current cross-border fires into Afghanistan as a response to imminent threats from insurgents safe havens in Kunar and Nuristan. The Pakistan Army reinforced their troops and operates with 25,000 troops along the border in the area of Nangarhar, Nuristan and Kunar (N2K).

Definition: Enemy-initiated attacks comprise enemy action (enemy-initiated direct fire, indirect fire, surface-to-air fire) and explosive hazard events, to include executed attacks only (improvised explosive device (IED) explosions / mine strikes).

Data Source: Afghan Mission Network (AMN) Combined Information Data Network Exchange (CIDNE) Database, as of 16 Feb 2012.



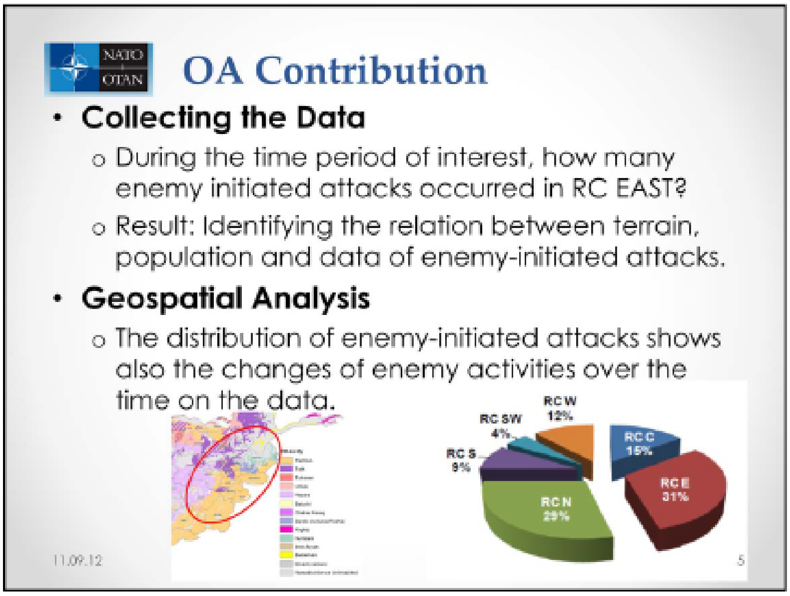
Slide 4:
What makes the situation different in RC East?:

•Distribution of Enemy-initiated Attacks?

•Terrain?

•Distribution of Own Troops?

I will try to give some answers to this question. RC East, the most populated region in Afghanistan, has seen a 34 percent decrease in EIA in Jan 2012 compared to Jan 2011. This is attributed to extreme winter weather conditions. However, RC East was the most violent RC between January 2011 and January 2012.



Slide 5:

RC East is a landlocked mountainous area with the highest mountains in Nuristan, Nangarhar, Kunar and Laghman (N2KL) Provinces. The terrain is a mixture of high peaks and river valleys in the east and shallow central plains. There are only few main routes along the Kabul River, the main river in eastern Afghanistan flowing through the city of Jalalabad into Pakistan, and the Kunar River, which flows south along the north-south axis of the Kunar Valley. The river valleys, surrounded by steep mountains, are natural obstacles affecting all movements through the region.2 RC East has a continental climate with very harsh winters, especially in the glaciated area around Nuristan Province, and hot summers in the low-lying areas of the Kabul River basin in Jalalabad in the southeast.

There are four main supply routes (MSRs) in the RC East area of operations (AOO), including southern routes into Kabul Province, Highway 1 through Ghazni and Wardak Provinces, Route UTAH through Logar, Paktika, Paktiya, and Khost Provinces, and Highway 7 through from Kunar Province through Laghman Province and conversely Nangarhar Province to Pakistan. RC East shares a 725-kilometer border with Pakistan's Northwest Frontier Province (NWFP) and Federally Administered Tribal Areas (FATA).

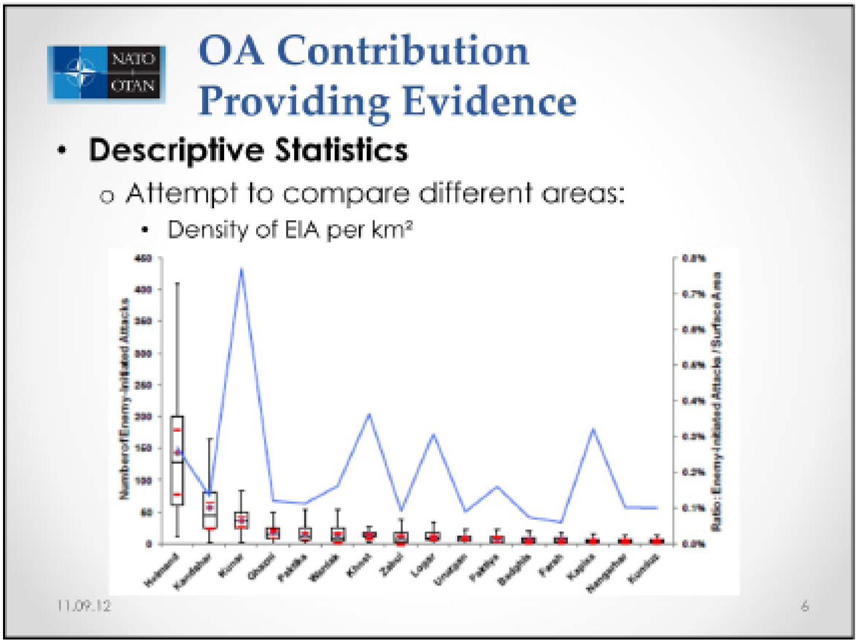
RC East has a large quantity of mineral deposits for Afghanistan, e.g. one of the world's richest deposits of lithium can be found in Ghazni Province.

The population in RC East is approximately 7.5 million people, 31 percent of the total Afghan population. The largest population areas are in Nangarhar (1.4 million) and Ghazni

Provinces (1.15 million). The most densely populated provinces are Kapisa (218 inhabitants per square kilometer), Nangarhar (197 inhabitants per square kilometer) and Khost Provinces (131 inhabitants per square kilometer). Comparatively, the population density in Kunar Province is only 86 inhabitants per square kilometer.

The region is compromised of various ethnic groups; the northwest is predominantly Hazara; the area north of Kabul is predominantly Tajik; and the mountainous regions along the border of Afghanistan and Pakistan is predominantly Pashtun with the area in and around Nuristan Province being Nuristani.

Data Source: CSO: Settled Population by Province (updated by CSO), as of 11 August 2011

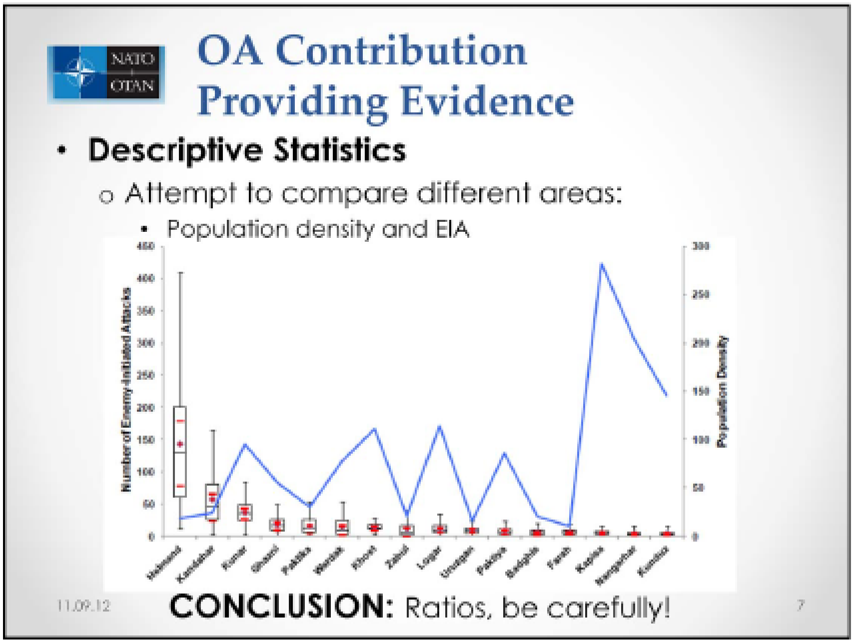


Slide 6:
Using a metric, the ratio of enemy-initiated attacks and the surface area of the province, can illustrate an additional perspective on how kinetic activity affects the population. The density of that ratio shows for Helmand Province, which is the province with the highest total number of enemy-initiated attacks (median of 127 weekly enemy-initiated attacks since January 2008) in Afghanistan the enemy-initiated attack level per square kilometer is only 0.22 percent; Kandahar Province with median of enemy-initiated attacks of 45 since January 2008 and enemy initiated-attack per square kilometer or 0.08 percent. Kunar Province in comparison, which has a median of 35 enemy-initiated attacks per week since January 2008, has an enemy-initiated attack per square kilometer level of 0.72 percent. This is the highest nationwide ratio of enemy-initiated attacks to surface area of a province.

Data Source: Ethnic distribution regarding results of the ANQAR Survey (wave 13), as of 23 September 2011.

The Landscan Global Population Project is a worldwide population database for estimating ambient populations at risk. Best available census counts are distributed to cells based on probability coefficients which, in turn, are based on road proximity, slope, land cover, and nighttime lights.

Kinetic activity is defined as primary type: {enemy action, explosive hazard, friendly action}; primary type: {direct fire, indirect fire, IED / mine strike, surface-to-air fire}

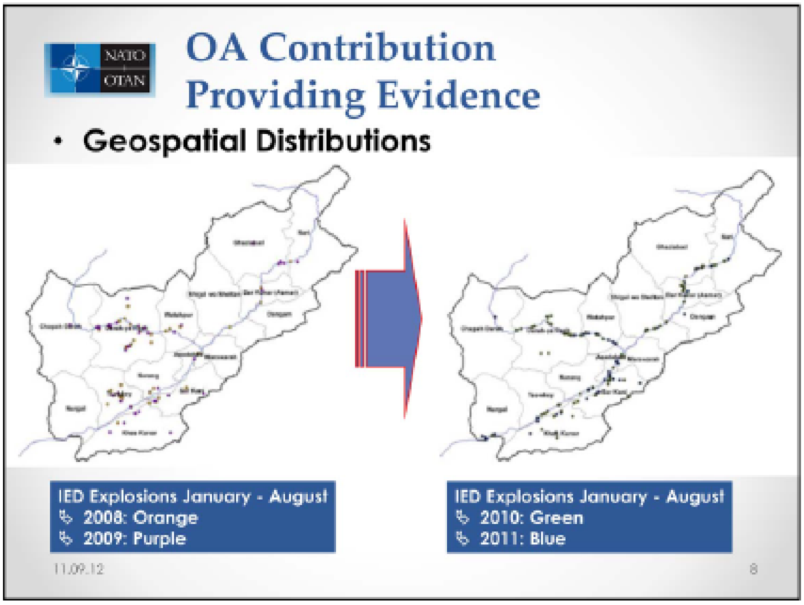


Slide 7:
Using Landscan 2009 data to estimate population and population density, we can better understand the number and distribution of Afghans affected by violence. The national per capita violence level is 5.9 events per 10,000 inhabitants for the period March – August 2011. By province there are wide variations. Helmand Province, which accounts for 3.7 percent of the population and 32 percent of all violence; Kandahar Province, which accounts for 4.5 percent of the population and 15 percent of all kinetic activity, and Kunar Province, which accounts for 1.6 percent of the population has 8 percent of all violence.

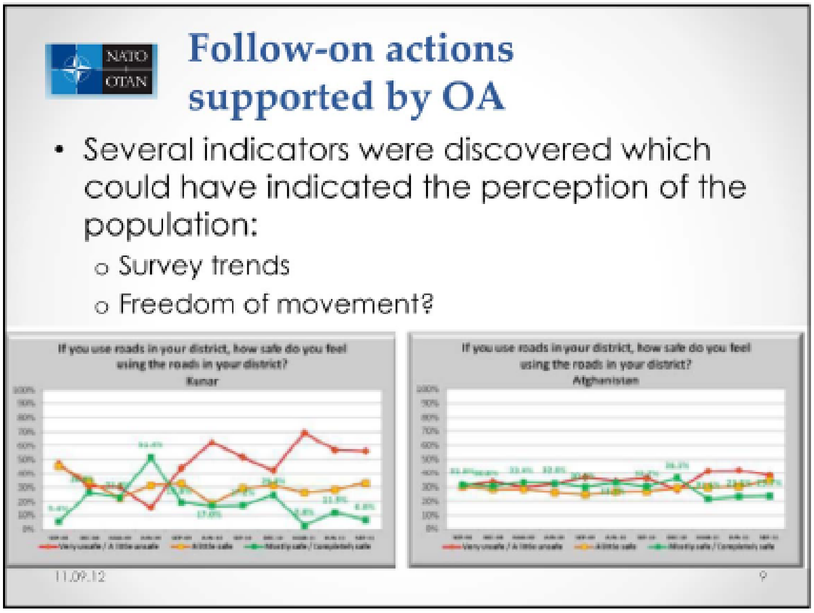
Data Source: Ethnic distribution regarding results of the ANQAR Survey (wave 13), as of 23 September 2011.

The Landscan Global Population Project is a worldwide population database for estimating ambient populations at risk. Best available census counts are distributed to cells based on probability coefficients which, in turn, are based on road proximity, slope, land cover, and nighttime lights.

Kinetic activity is defined as primary type: {enemy action, explosive hazard, friendly action}; primary type: {direct fire, indirect fire, IED / mine strike, surface-to-air fire}



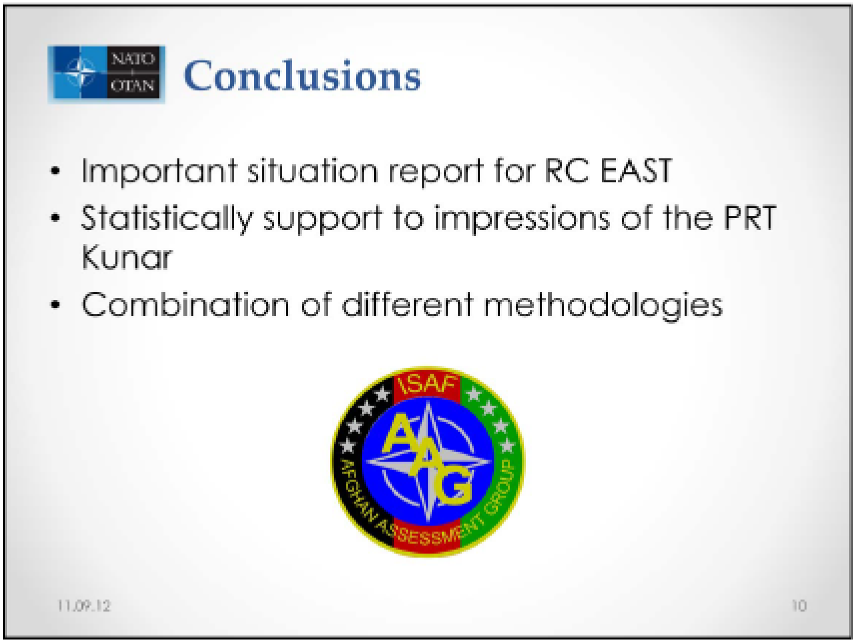
Slide 8:
The rise of the restrictions of freedom of movement for inhabitants of the Kunar Province is also reflected in an increase of IED explosions along the MSR. This slide shows the increase and the distribution of IED explosions in Kunar for the period from January to August for 2008, 2009, 2010, 2011.



Slide 9:
The results from ANQAR Survey, conducted in September 2011, support this trend by indicating a lack of freedom of movement in Kunar Province.

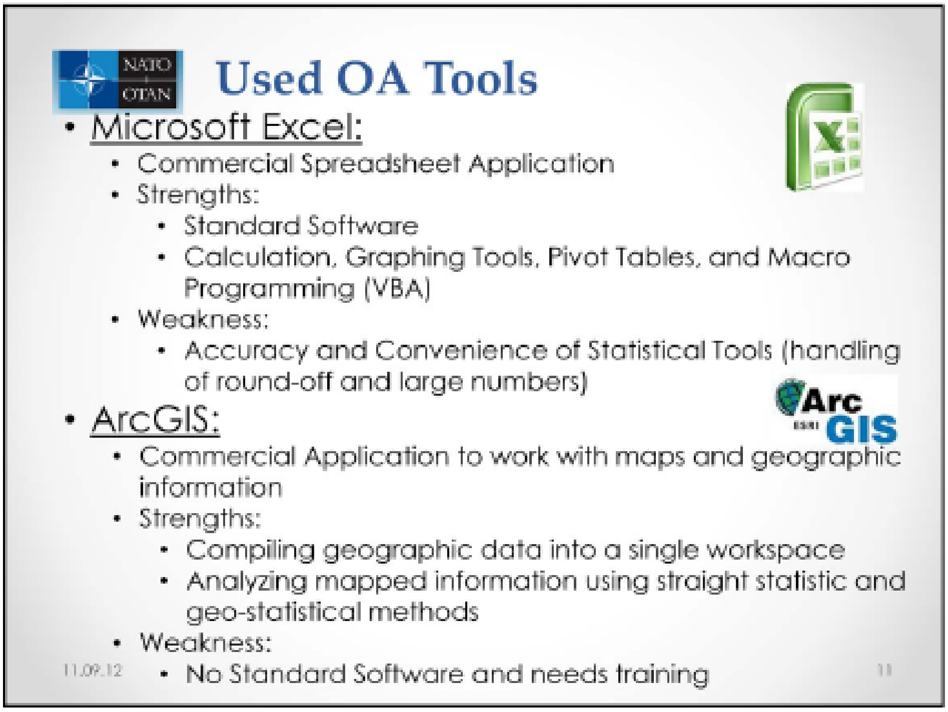
ANQAR: Afghan Nationwide Quarterly Assessment Research

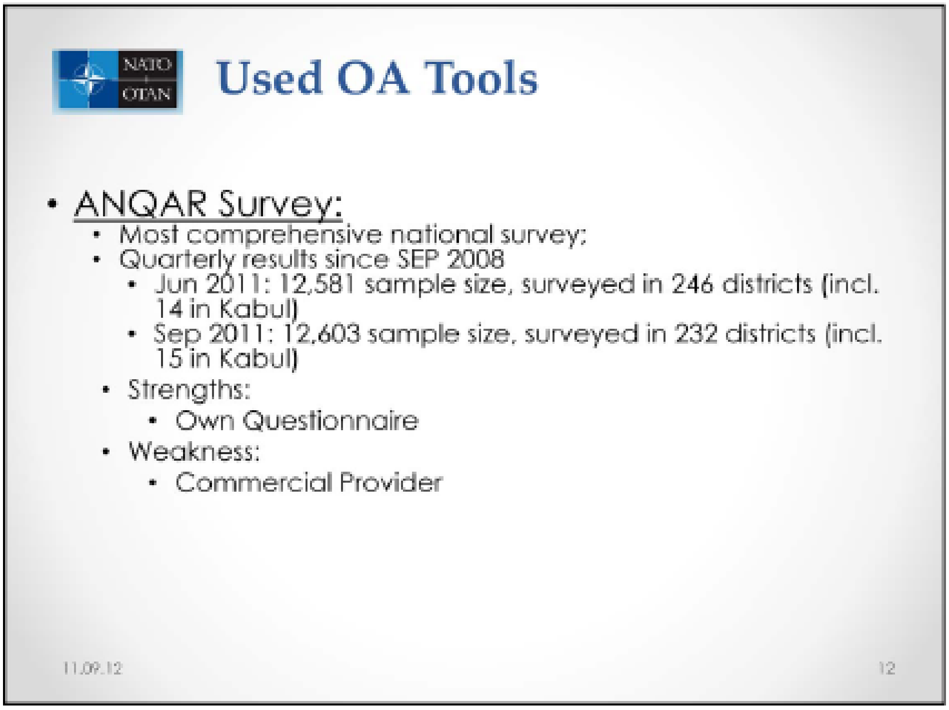
Data Source: ANQAR Survey, as of September 2011.



Slide 10:
Conclusions.
Several factors contribute to the unique and segmented violence trends in RC East - disparate and highly distributed enemy activity; highly restrictive terrain; and the proximity to Pakistan. Insurgent activity in RCs South and Southwest tends to be concentrated in key populated areas, which provides better opportunities for control.

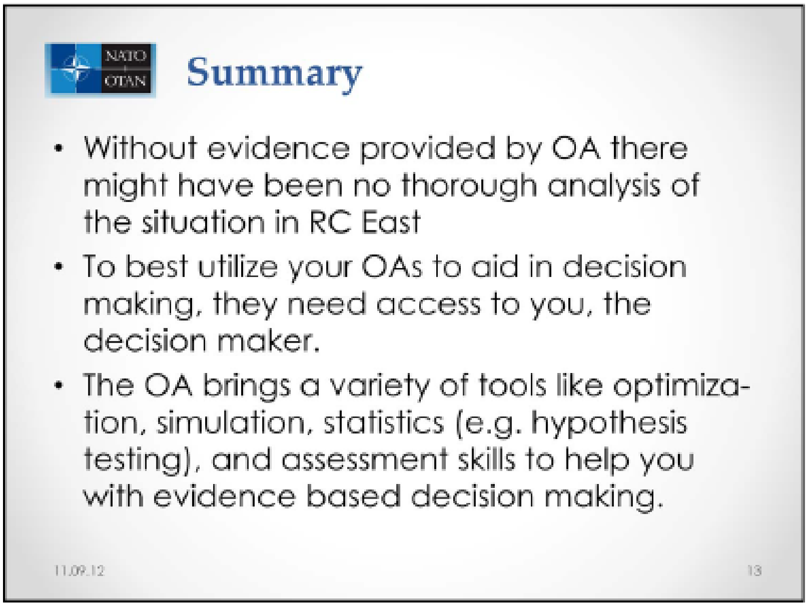
Recent Combined Team and Coalition Force successes in the southern portions of Afghanistan have led to a steady and progressive decrease in levels of significant activity (SIGACTs) and violence. However, the situation in RC east is different. The differences are not only the increasing of security incidents, also in particular the terrain and the kinds of attacks are different. Friendly forces movements are only possible along the small valleys, the mountainous area offer the insurgents various hiding-places. Further on, the far eastern part of the region is one of the poorest areas of Afghanistan due to a lack of infrastructure. Current cross-border fires into Afghanistan as a response to imminent threats from insurgents safe havens in Kunar and Nuristan. The Pakistan Army reinforced their troops and operates with 25,000 troops along the border in the area of Nangarhar, Nuristan and Kunar (N2K).

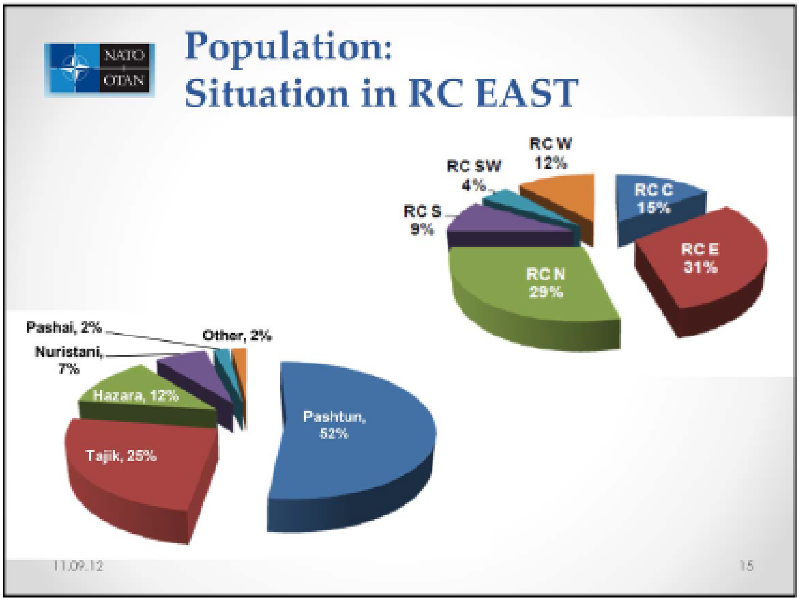




Slide 12:

ANQAR: Afghan Nationwide Quarterly Assessment Research



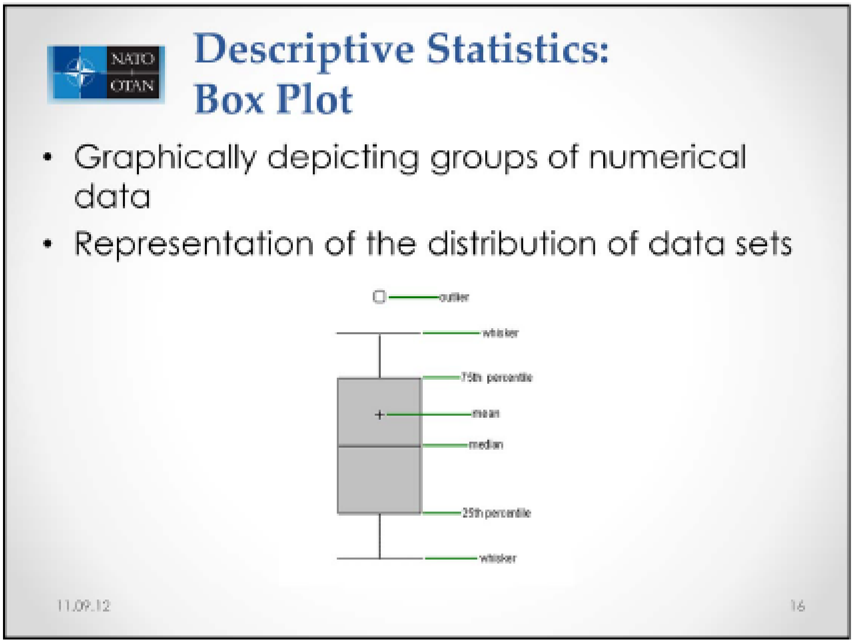


Slide 15:

The population in RC East is approximately 7.5 million people, 31 percent of the total Afghan population. The largest population areas are in Nangarhar (1.4 million) and Ghazni Provinces (1.15 million). The most densely populated provinces are Kapisa (218 inhabitants per square kilometer), Nangarhar (197 inhabitants per square kilometer) and Khost Provinces (131 inhabitants per square kilometer). Comparatively, the population density in Kunar Province is only 86 inhabitants per square kilometer.

The region is compromised of various ethnic groups; the northwest is predominantly Hazara; the area north of Kabul is predominantly Tajik; and the mountainous regions along the border of Afghanistan and Pakistan is predominantly Pashtun with the area in and around Nuristan Province being Nuristani.

Data Source: CSO: Settled Population by Province (updated by CSO), as of 11 August 2011



Slide 16:
Short introduction of box plots.

In descriptive statistics, a **box plot** (also known as a **box-and-whisker diagram**) is a convenient way of graphically depicting groups of numerical data through their five-number summaries: the smallest observation (sample minimum), lower quartile (Q1), median (Q2), upper quartile (Q3), and largest observation (sample maximum). A box plot may also indicate which observations, if any, might be considered outliers.

The Impact Factor box plot depicts the distribution of Impact Factors for all journals in the category. The horizontal line that forms the top of the box is the 75th percentile (Q3). The horizontal line that forms the bottom is the 25th percentile (Q1). The horizontal line that intersects the box is the median Impact Factor for the category. The cross represents the mean value.

Horizontal lines above and below the box, called *whiskers*, represent maximum and minimum values. The top whisker is the smaller of the following two values:

•the maximum Impact Factor (IF)

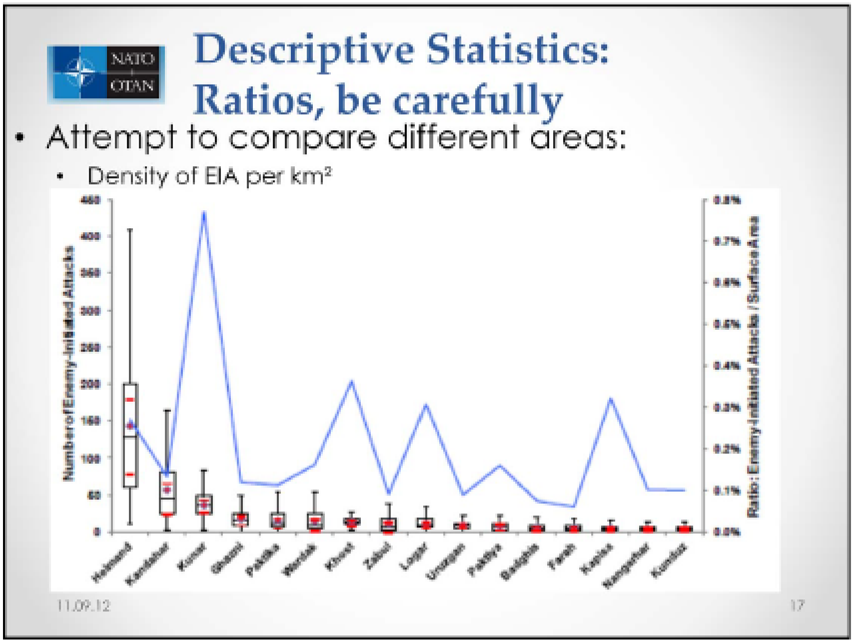
Q3 IF + 3.5(Q3 IF - Q1 IF)

The bottom whisker is the larger of the following two values:

•the minimum Impact Factor (IF)

Q3 IF - 3.5(Q3 IF - Q1 IF)

An circle represents an outlier, which is a value greater than the value represented by the top whisker. An asterisk represents a "far" outlier, which is a value greater than the sum of the value represented by the top whisker and 5(Q3 IF - Q1 IF).

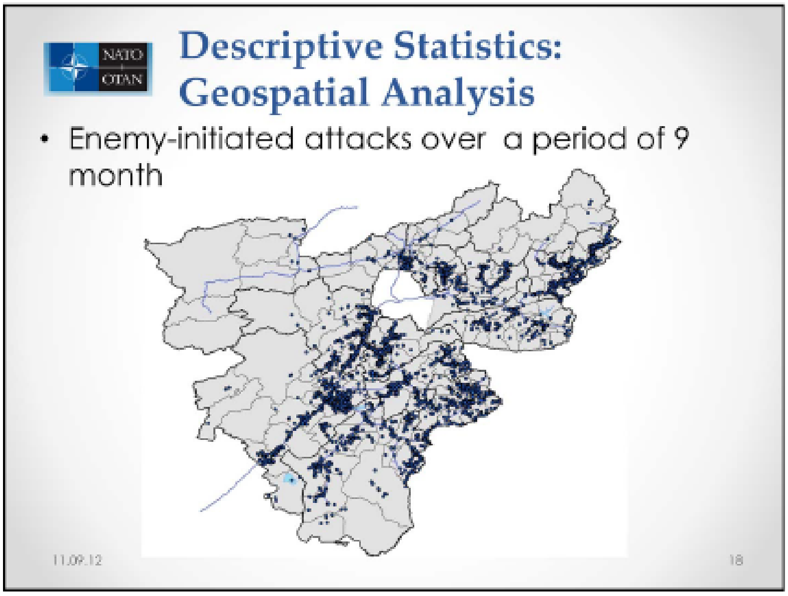


Slide 17:
Using a metric, the ratio of enemy-initiated attacks and the surface area of the province, can illustrate an additional perspective on how kinetic activity affects the population. The density of that ratio shows for Helmand Province, which is the province with the highest total number of enemy-initiated attacks (median of 127 weekly enemy-initiated attacks since January 2008) in Afghanistan the enemy-initiated attack level per square kilometer is only 0.22 percent; Kandahar Province with median of enemy-initiated attacks of 45 since January 2008 and enemy initiated-attack per square kilometer or 0.08 percent. Kunar Province in comparison, which has a median of 35 enemy-initiated attacks per week since January 2008, has an enemy-initiated attack per square kilometer level of 0.72 percent. This is the highest nationwide ratio of enemy-initiated attacks to surface area of a province.

Data Source: Ethnic distribution regarding results of the ANQAR Survey (wave 13), as of 23 September 2011.

The Landscan Global Population Project is a worldwide population database for estimating ambient populations at risk. Best available census counts are distributed to cells based on probability coefficients which, in turn, are based on road proximity, slope, land cover, and nighttime lights.

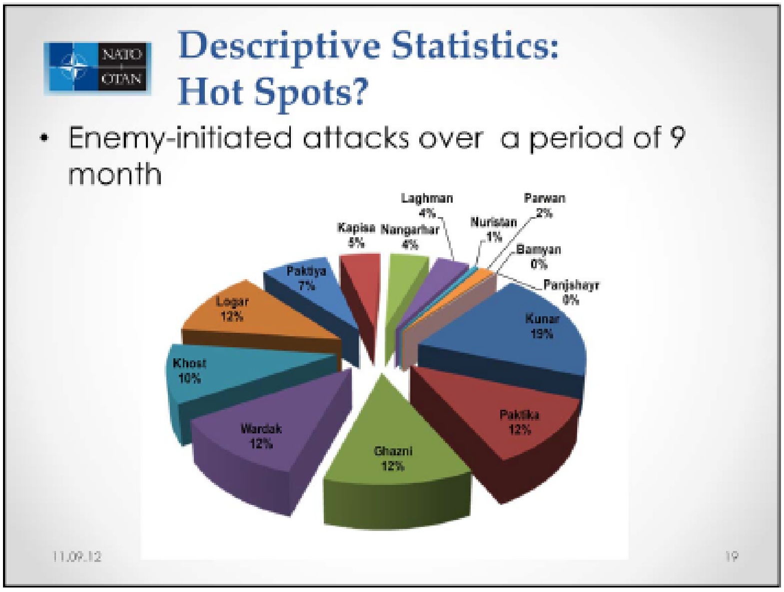
Kinetic activity is defined as primary type: {enemy action, explosive hazard, friendly action}; primary type: {direct fire, indirect fire, IED / mine strike, surface-to-air fire}



Slide 18:

This map shows that enemy-initiated attacks are concentrated in Kunar, Khost, and Kapisa Provinces as well as near the Ring Road in Logar, Wardak, and Ghazni Provinces.

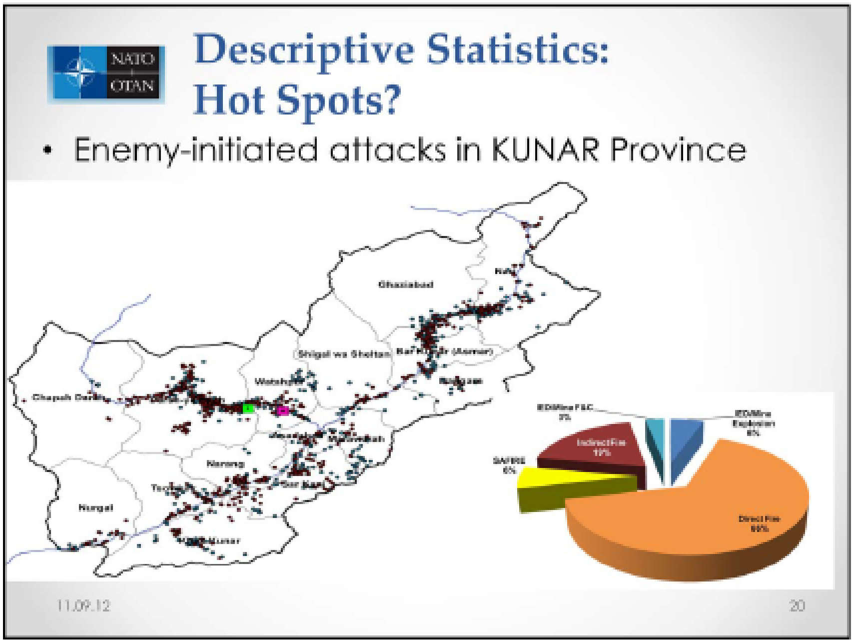
Data Source: AMN CIDNE



Slide 19:

This map indicates the distribution of security incidents by province. Security incidents are concentrated in Kunar, Logar, Paktika, Paktiya, Wardak, and Ghazni Provinces over a period of nine month.

Data Source: AMN CIDNE

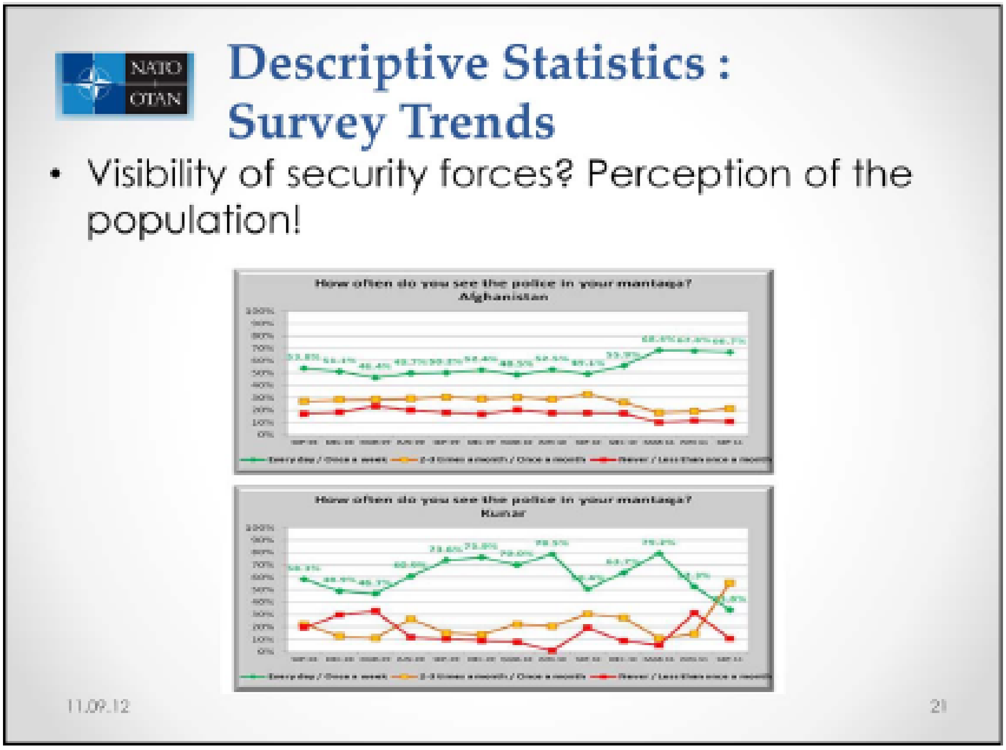


Slide 20:

This map shows a small number of incidents along the province's border with Pakistan, in 2011 there was a significant increase of indirect fire (IDF) events along that border area. The concentrations of IDF events occurred around Asadabad, in Darah-ye Pech, in Bar Kunar District, and along the lines of communication (LOC) in Ghaziabad and Nari Districts.

Similarly to IDF events in Kunar Province, surface-to-air fire (SAFIRE) events have increased slightly from 109 to 130 events for a period of 8 month 2010 compared to the 2011. The level of IED explosions in Kunar Province has remained the same during the same periods.

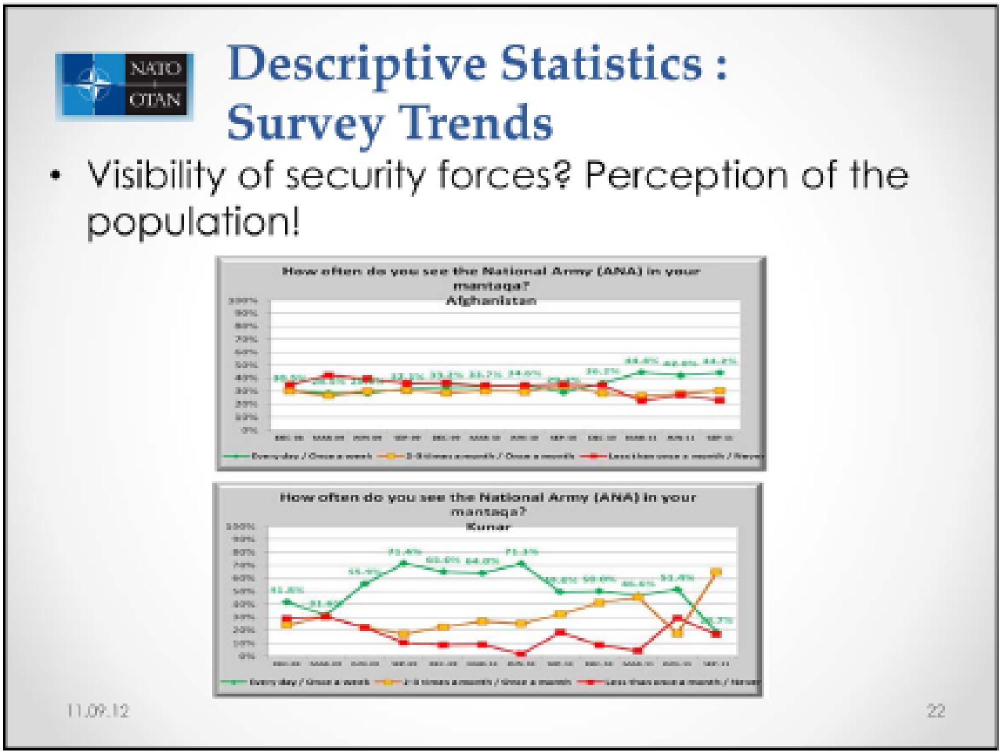
Data Source: AMN CIDNE



Slide 21:
POLICE!
The results from ANQAR Survey, conducted in September 2011, support this trend by indicating an overall lack of visibility of security forces in Kunar Province.

ANQAR: Afghan Nationwide Quarterly Assessment Research

Data Source: ANQAR Survey, as of September 2011.



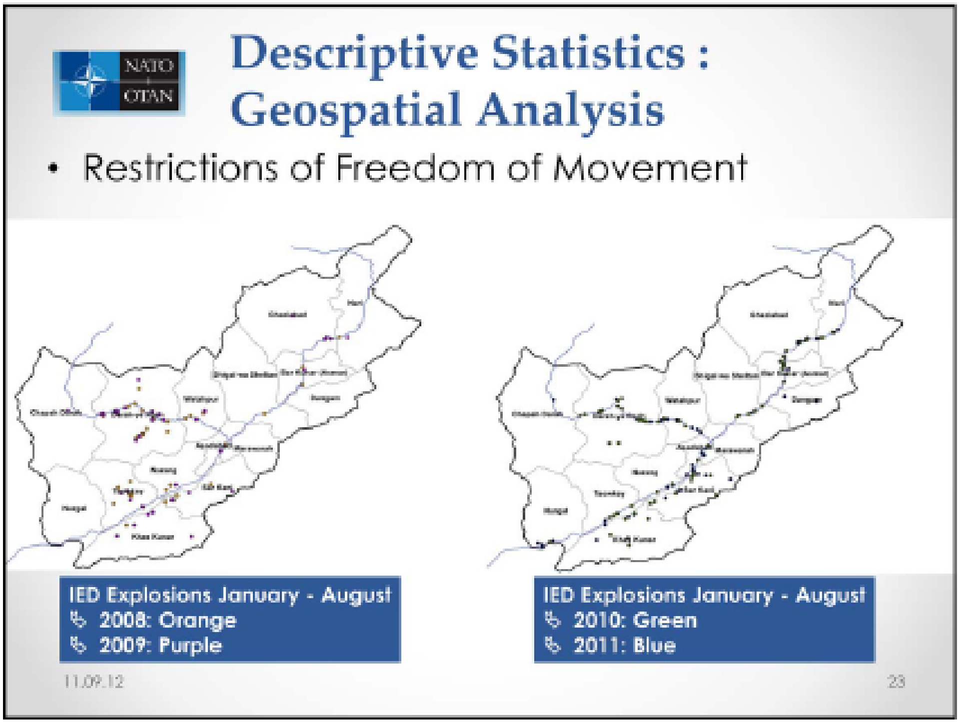
Slide 22:

ANA

The results from ANQAR Survey, conducted in September 2011, support this trend by indicating an overall lack of visibility of security forces in Kunar Province.

ANQAR: Afghan Nationwide Quarterly Assessment Research

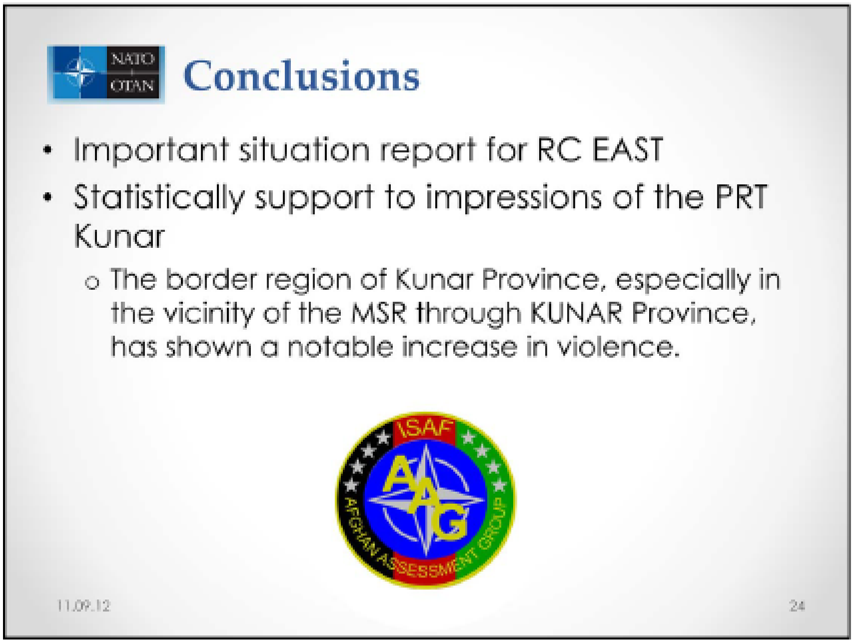
Data Source: ANQAR Survey, as of September 2011.



Slide 23:

The rise of the restrictions of freedom of movement for inhabitants of the Kunar Province is also reflected in an increase of IED explosions along the MSR. This slide shows the increase and the distribution of IED explosions in Kunar for the period from January to August of the last four years.

Data Source: AMN CIDNE



Slide 24:
Conclusions.
Several factors contribute to the unique and segmented violence trends in RC East - disparate and highly distributed enemy activity; highly restrictive terrain; and the proximity to Pakistan. Insurgent activity in RCs South and Southwest tends to be concentrated in key populated areas, which provides better opportunities for control.

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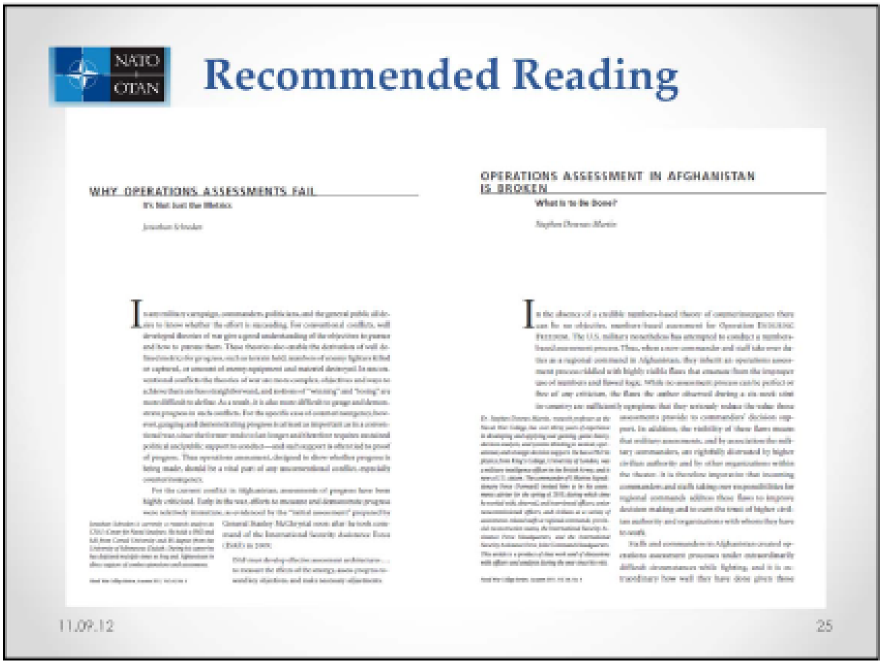
Data Source: COMISAF Morning Update: Combined Joint Intelligence Operations Center – Afghanistan, Pakistan Border Update, as of 09 October 2011.

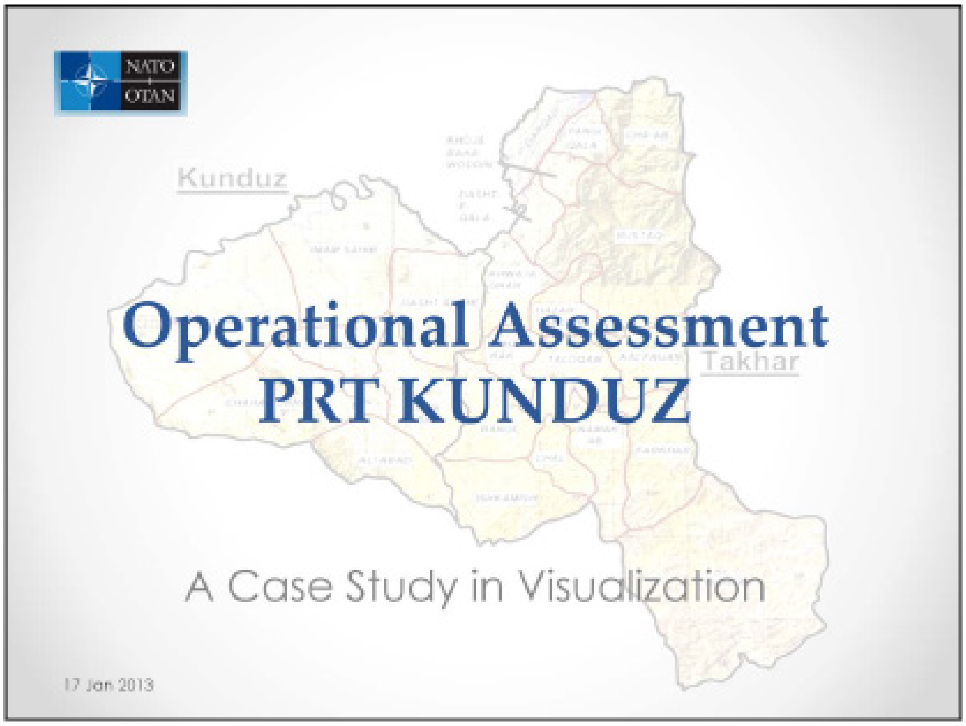


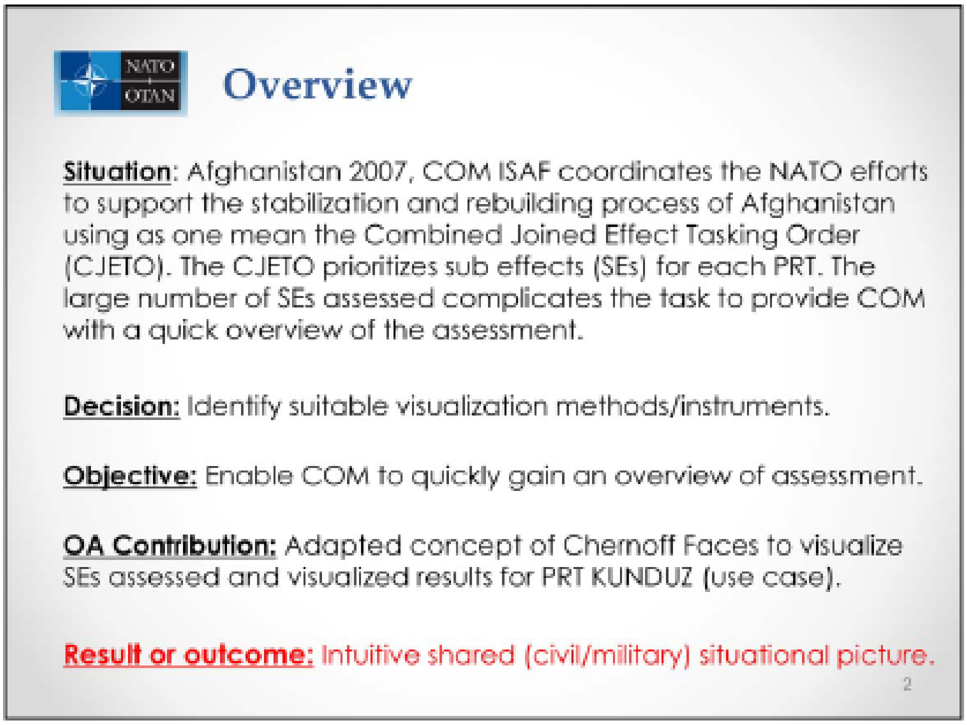
Slide 25:
Recommended readings:
- Why operations assessments fail (Dr. Jonathan Schroden, CNA)
- Operations Assessment in Afghanistan is broken (Dr. Stephen Downes-Martin, NWC)

A.2.7 Chernoff Faces

INSTRUCTIONAL MODULE SUMMARY

Title	Operational Assessment PRT KUNDUZ: A Case Study in Visualization
Faculty Name(s)	Bundeswehr Planning Office, Ottobrunn, DEU
Length	30 minutes
Learning Objectives	Understand that visualization methods can be used to improve the situational awareness of the decision-maker.
Outcomes	As the result of this module, participants will be able to: Recognize similar applications where an analysis by OA staff could support the decision-making process by improving the situational awareness.
Content Outline	Case Study: Operational Assessment PRT KUNDUZ.
Materials	None.
Methods	100% Lecture 0% Class Exercises. ____ % Break Outs.
Exercise(s)	None.
Break Outs	___ Yes X No. __#___ participants in each break out group.
Discussion Questions	Did you have a similar case in the past? Can you think of a current case in your area of responsibility where visualization methods could/do improve situational awareness?

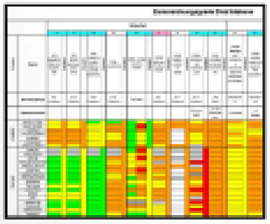


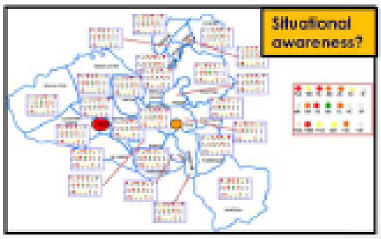


In order to describe the current situation in the 24 districts (PRT KUNDUZ), the CJETO required the assessment of 20 effects/sub effects. In this context, the Chernoff Faces (Afghan Glyphs) were intended as an instrument for complexity reduction.

Situation

- Situational awareness is based on the assessment of a large number of sub effects
- An intuitive shared holistic situational picture, which merges civil and military assessment and allows the commander to get a quick overview is missing



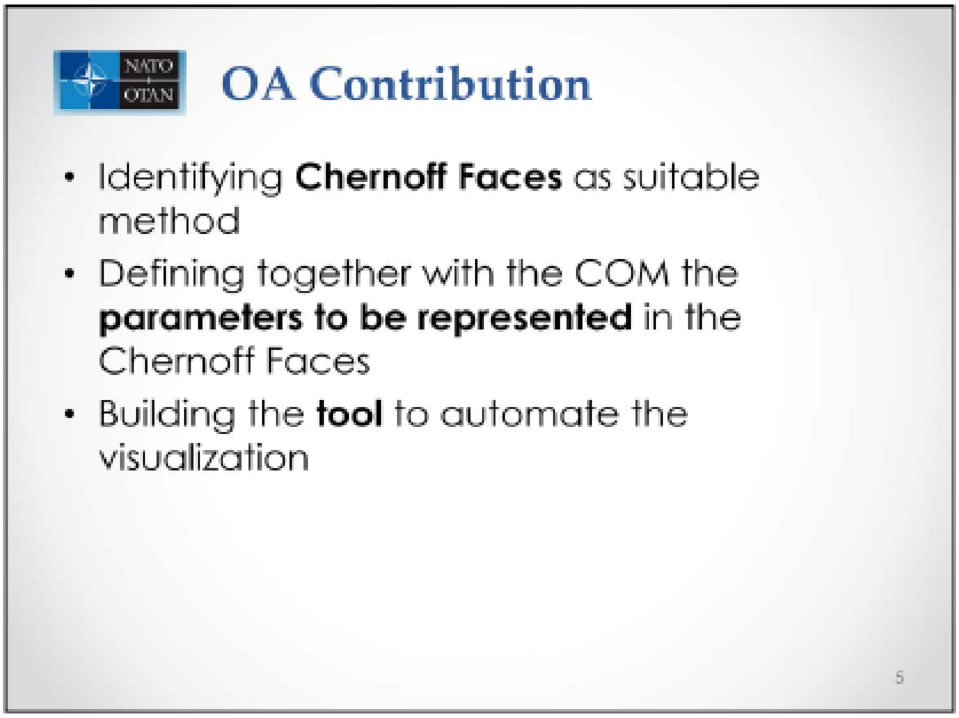


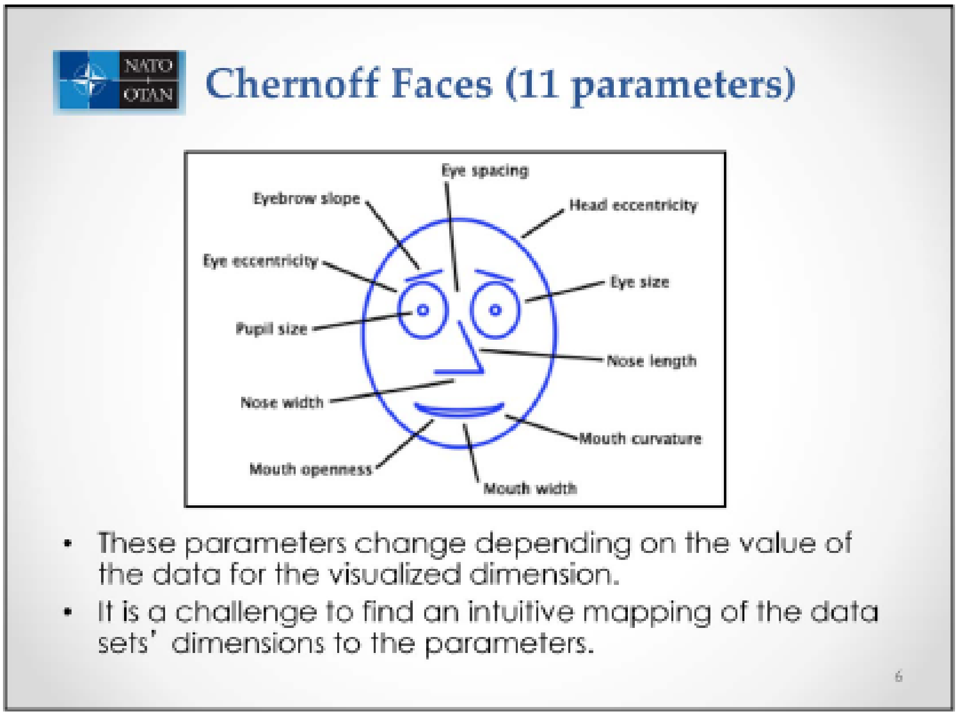
3

Approach

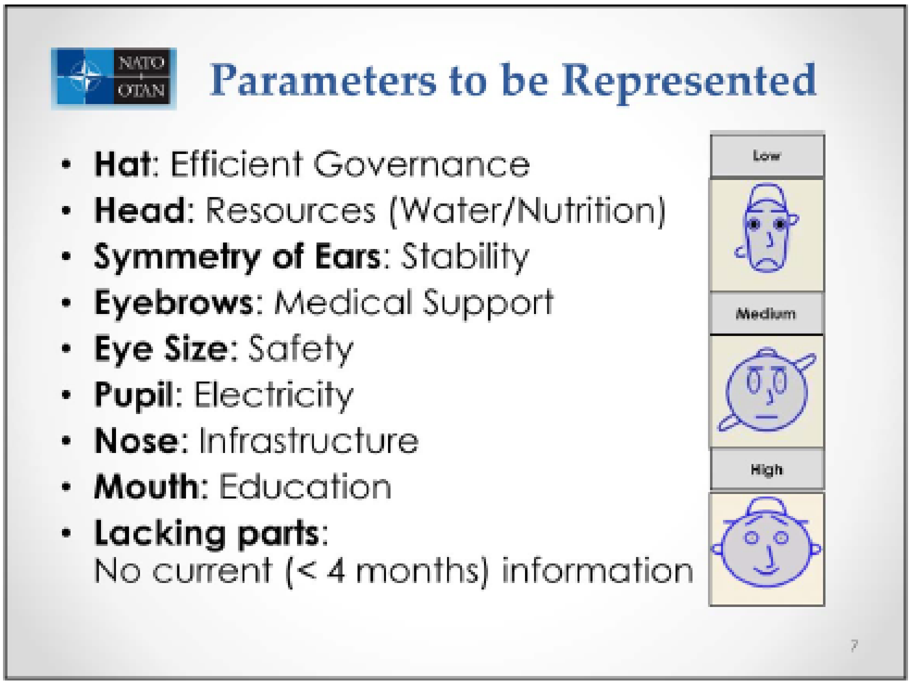
- **Identify suitable visualization methods/instruments** to enable COM to quickly gain an overview of the assessment
- **Structure the assessment** with the the high number of sub effects to suitable parameters
- **Implement an automated tool** to generate the visualization from the existing raw data

4

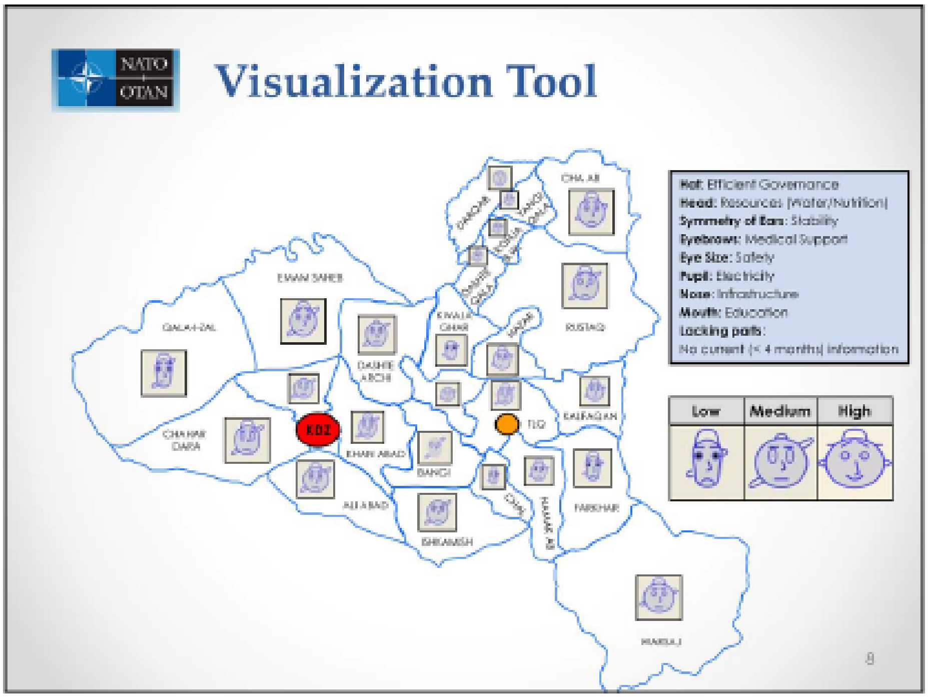




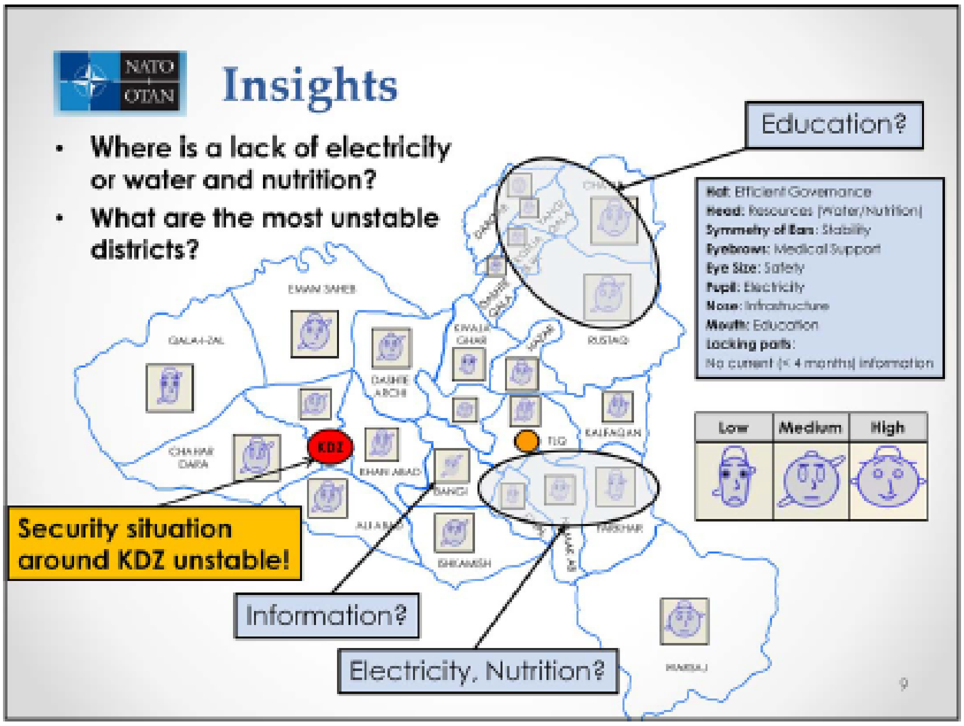
Chernoff Faces were invented by Herman Chernoff, an american applied mathematician, statistician and physicist. Their purpose is to visualize multivariate data (see slide 18).



Because of the varying perceived importance of the features, the mapping (e.g. safety to eye size) should be carefully chosen.



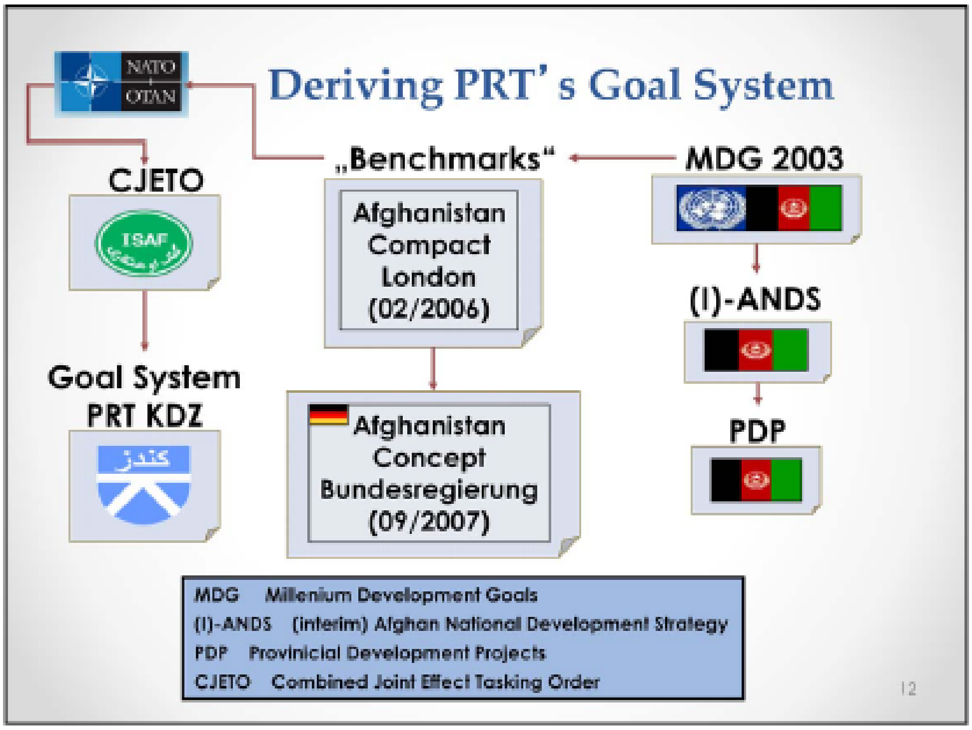
The blue box (top right) contains the mapping of relevant variables to the features of the faces (see previous slide). The situation in each of the 24 districts (PRT KUNDUZ) – described considering eight distinct variables – is visualized by a Chernoff Face.



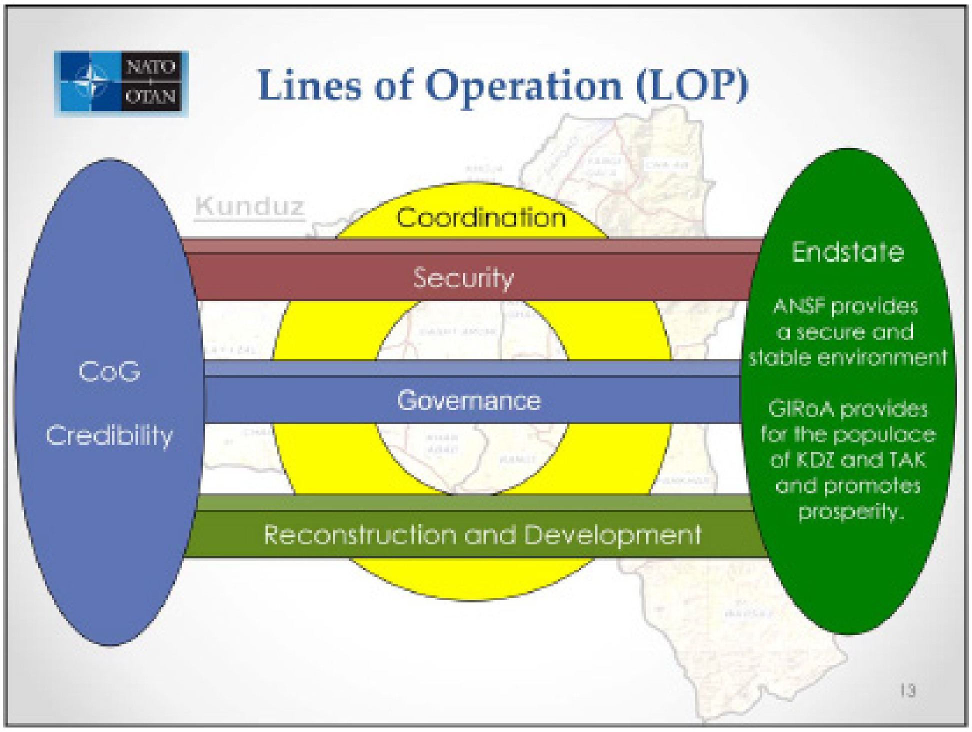
Summary

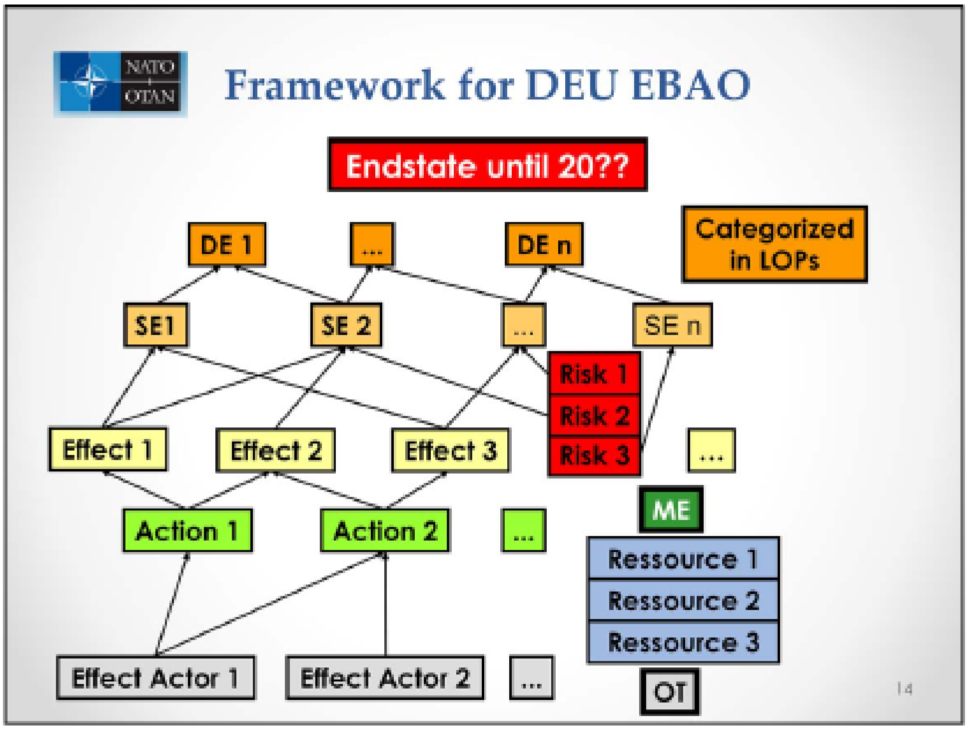
- Visualisation Method identified by OA and identification of relevant parameters together with the COM provides an Intuitive shared (civil/military) situational picture.
- To best utilize your OAs to aid in situational awareness and decision making, they need access to you, the decision maker.
- The OA brings a variety of tools like visualisation, optimization, simulation, statistics, and assessment skills to help you with evidence based decision making.

10

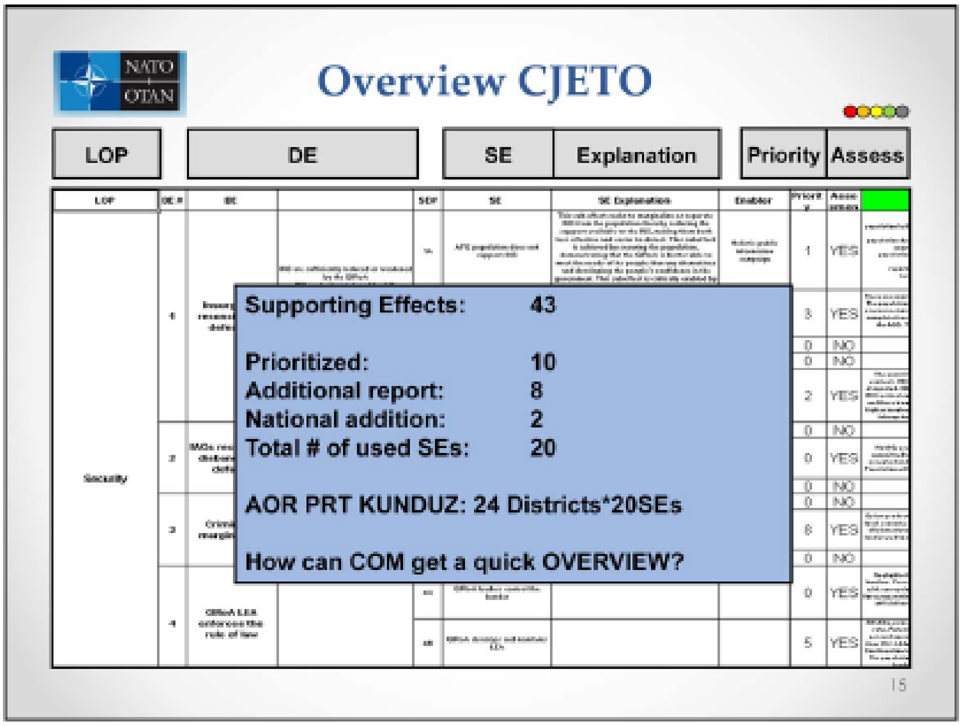


This slide indicates the differenct elements influencing the goal setting process.





EBAO = Effects-Based Approach to Operations



„Ordered" Supporting Effects (CJETO)

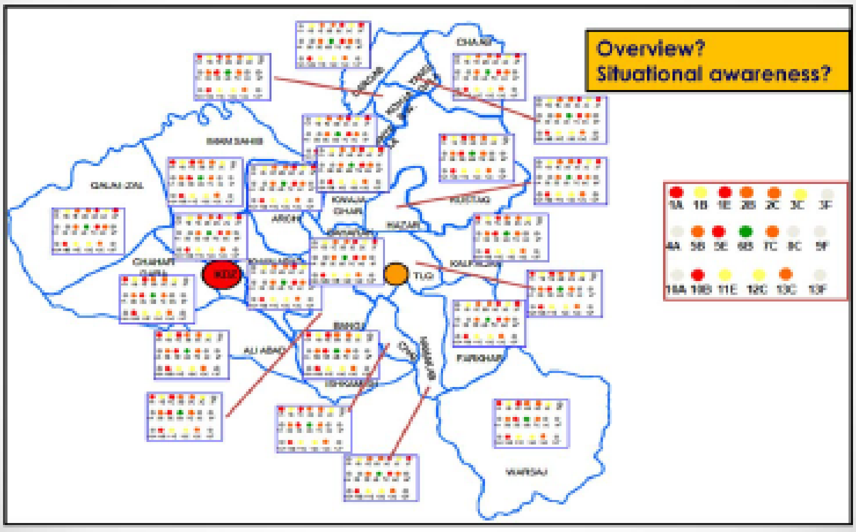
SE#	1A	1B	1E	2B	3B	4A	4B	5B	6A
SE	AFG population does not support INS	INS denied sanctuary within AFG	INS unable to conduct effective combat operations	IAGs neutralized	GIRoA combat narcotics industry	GIRoA leaders control the border	GIRoA develops and maintains LEA	ANA provides a secure environment	GIRoA develops and maintains a nationwide road and transportation system
SE#	**6B**	**7C**	**9A**	**9B**	**10A**	**11B**	**11D**	**13C**	**13F**
SE	GIRoA provides water and power to AFG population	People engage in education	GIRoA develops agriculture	GIRoA develops rural infrastructure, irrigation and water management	GIRoA coordinates and delivers effective humanitarian relief to AFG population	GIRoA develops and maintains a judical system	GIRoA prosecutes and/or removes corrupt GIRoA officials	The President appoints qualified officials	GIRoA communicates to the AFG people

In yellow: Prioritized SEs
In white: Not prioritized but report on them

INS = Insurgents
IAG = Illegal Armed Groups

16

Situational Picture KUNDUZ & TAHKAR



17

This slide shows the old approach to visualization.

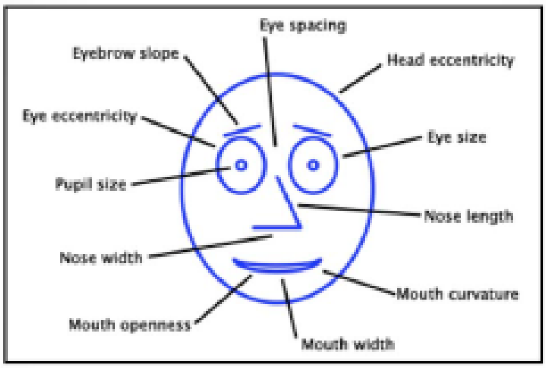
What are Chernoff Faces?

- The Russian mathematician Chernoff invented – most likely coincidentally – a visualization technique for multivariate data. Chernoff visualized his data sets with facial expressions.
- Multivariate data means that there are many dimensions within data sets.
- One of the reasons why this visualization technique works so well is because human beings are trained to interpret facial expressions fairly quickly.

Chernoff, Herman (1973): The use of faces to represent points in k-dimensional space graphically, in: Journal of the American Statistical Association, 68 (#342): 361-368.

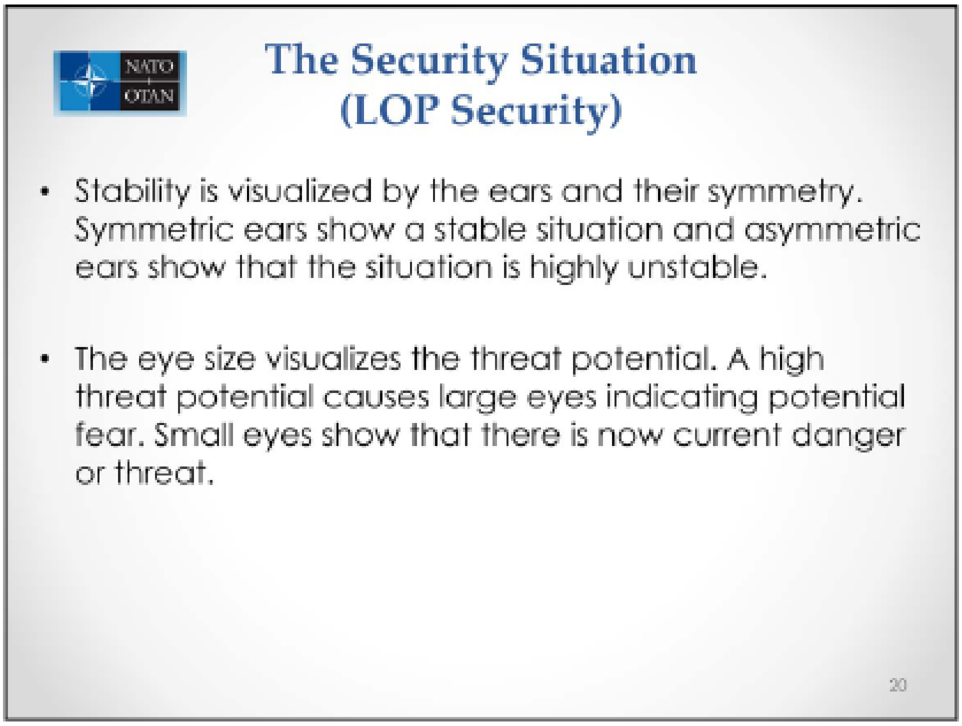
18

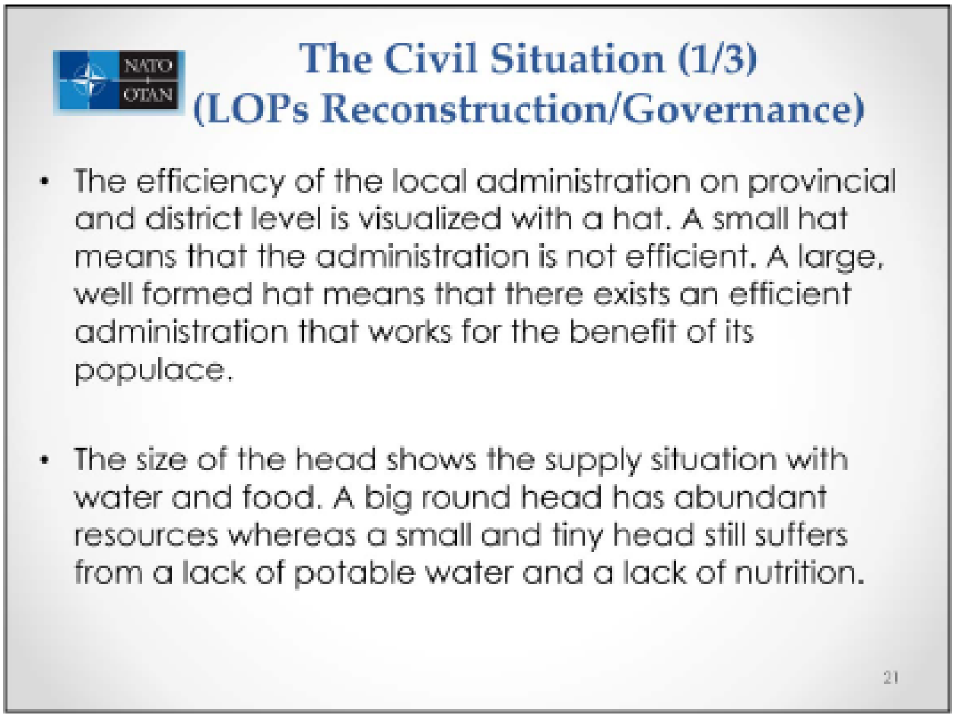
Chernoff Faces (11 parameters)



- These parameters change depending on the value of the data for the visualized dimension.
- It is a challenge to find an intuitive mapping of the data sets' dimensions to the parameters.

19


NATO OTAN
The Security Situation
(LOP Security)
• Stability is visualized by the ears and their symmetry. Symmetric ears show a stable situation and asymmetric ears show that the situation is highly unstable.
• The eye size visualizes the threat potential. A high threat potential causes large eyes indicating potential fear. Small eyes show that there is now current danger or threat.
20


NATO OTAN
The Civil Situation (1/3)
(LOPs Reconstruction/Governance)
• The efficiency of the local administration on provincial and district level is visualized with a hat. A small hat means that the administration is not efficient. A large, well formed hat means that there exists an efficient administration that works for the benefit of its populace.
• The size of the head shows the supply situation with water and food. A big round head has abundant resources whereas a small and tiny head still suffers from a lack of potable water and a lack of nutrition.
21

The Civil Situation (2/3) (LOPs Reconstruction/Governance)

- The pupils indicate how much energy is supplied to a district. If there is no efficient power supply the pupils are wide open to indicate that it is dark and the pupils adapt appropriately. Small pupils show that there is enough light indicating an efficient power supply.

- The eyebrows indicate how well the health provision functions. Raised eyebrows indicate a happy face meaning that the healthcare system works efficiently. The angry looking face shows that there is no efficient health care provision annoying the populace.

22

The Civil Situation (3/3) (LOPs Reconstruction/Governance)

- The length of the nose indicates the state of the infrastructure. A very short nose can be associated with a lack of paved roads. A long nose shows that the infrastructure is extended and functional between district centres and main villages.

- The mouth shows how well the educational system functions. Male (right part of the mouth) and female (left part of the mouth). A big smile means that the educational system, including schools and vocational skill training, is fully functional. A sad expression means that the education is not working efficiently.

23

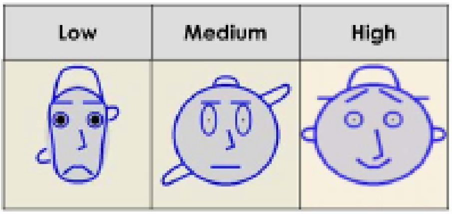
Matching Visualization and SEs

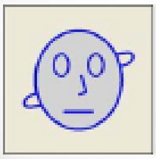
Visualization	Parameter	Supporting Effects Criterion
Eye Size	Safety	1E,3C Max Value criterion
Symetry of Ears	Stability	1A, 1B, 2B, 3C, 4B Average
Hat size	Efficency of local Govm't	11B, 11D, 13C, 13F Average
Head Size	Water/ Nutrition	6B, 9A Average
Pupils	Power Supply	6B
Eye Browse	Health Care	8A
Nose	Infrastructure	6A, 6B Average
Mouth Right hand	Educational Level Boys	7C
Mouth left hand	Educational Level Girls	7C

Resulting value: High, Medium, Low (simple if-statements)

24

Transition to Afghan Glyph





- This figure shows that we have no current information on the administration's efficiency and about the status of power supply.
- It also shows that the infrastructure and the educational system have medium values.
- The security situation is mostly calm and more or less stable.

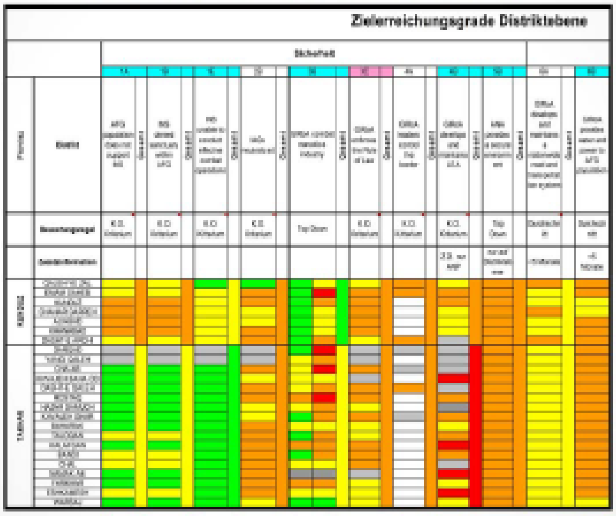
25

Use Case: Campaign Assessment Tool

- Intuitive shared situational picture.
- Merge civil and military situational assessment.
- Standardize visualization of different data.
- Integrate system down to raw data.

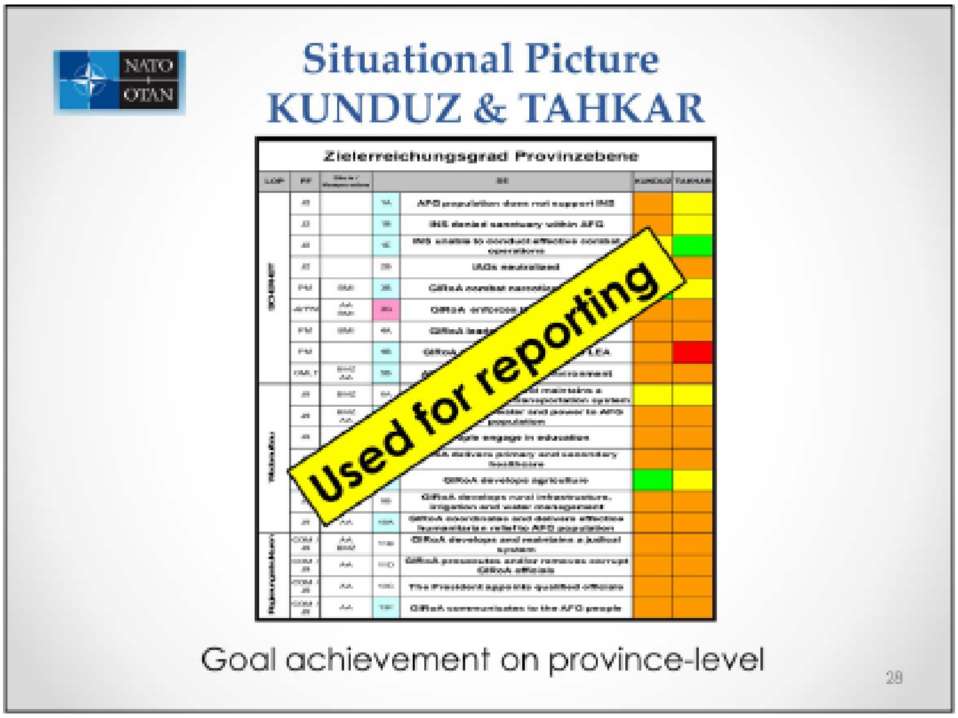
26

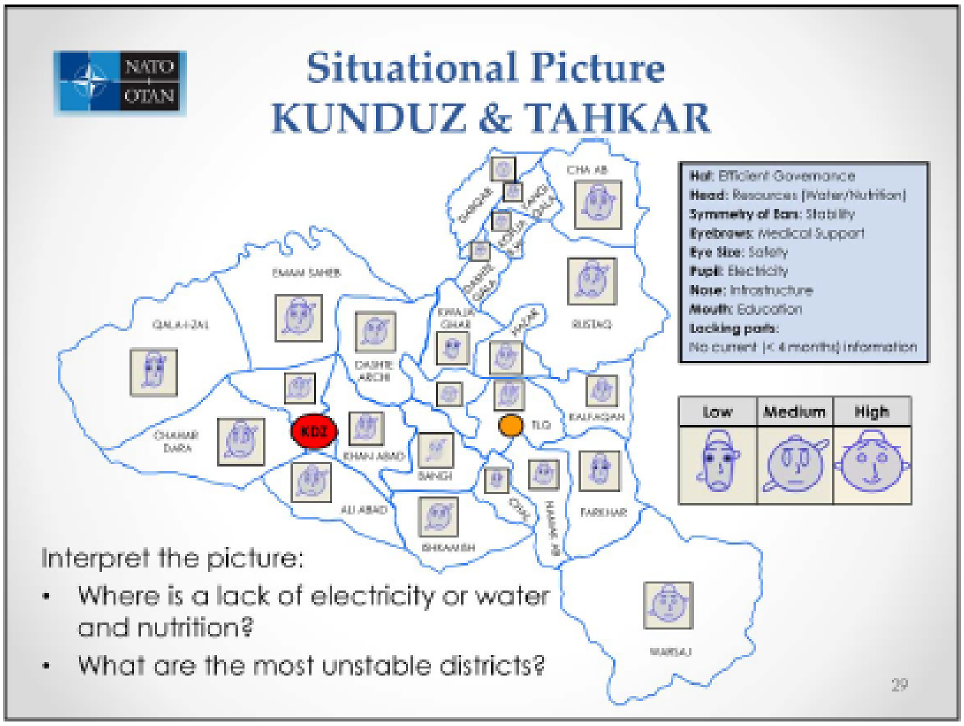
Situational Picture KUNDUZ & TAHKAR

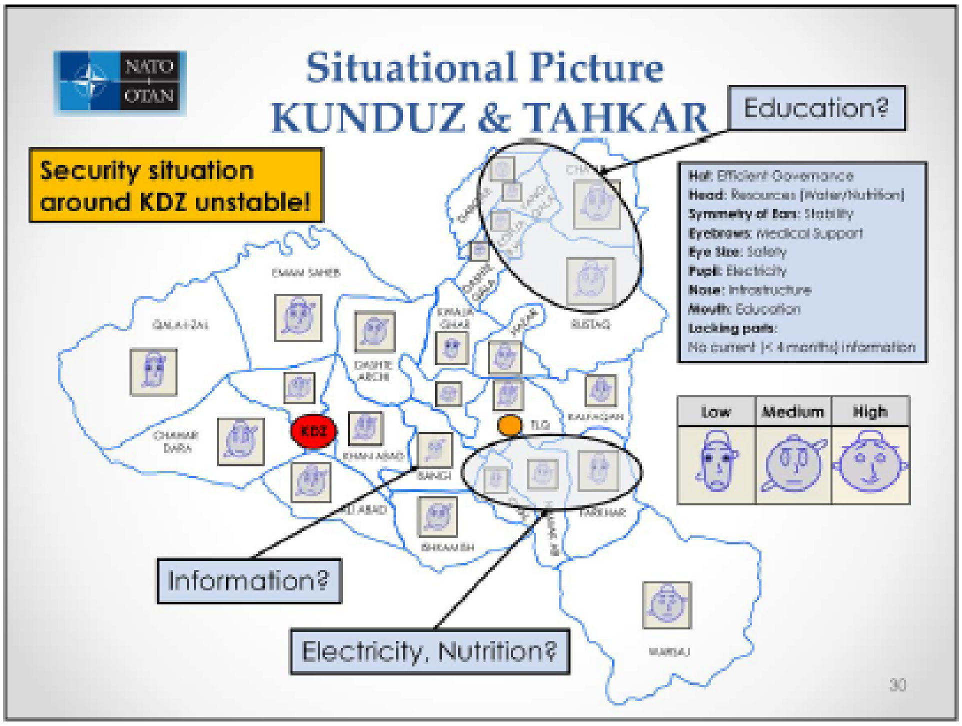


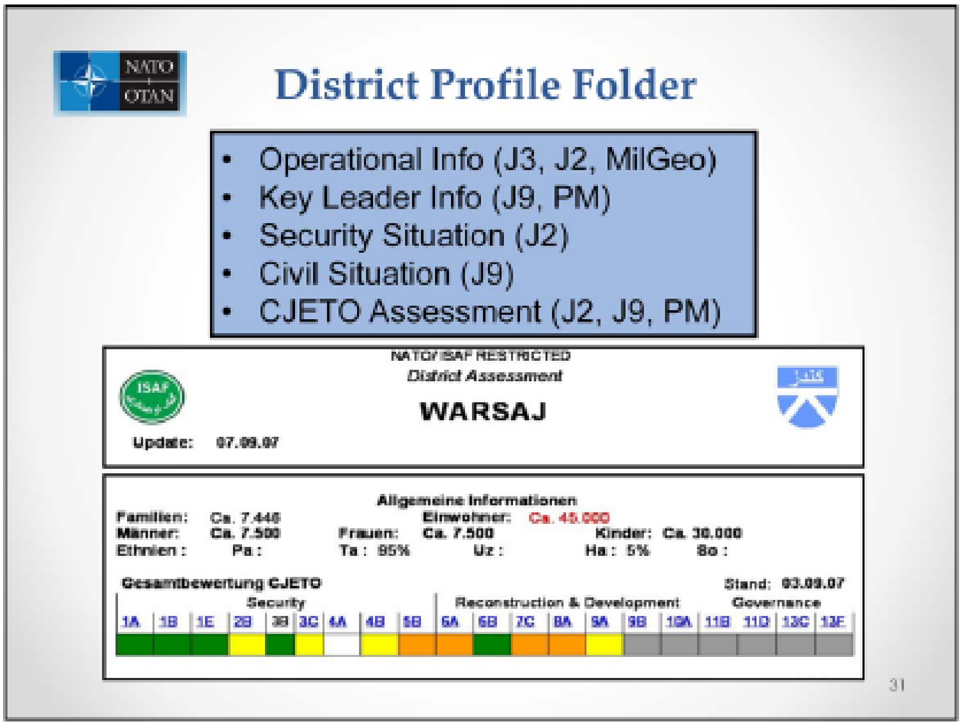
Goal achievement on district-level

27


NATO
OTAN
Situational Picture
KUNDUZ & TAHKAR
Zielerreichungsgrad Provinzebene
Used for reporting
Goal achievement on province-level
28


NATO
OTAN
Situational Picture
KUNDUZ & TAHKAR
Hat: Efficient Governance
Head: Resources (Water/Nutrition)
Symmetry of Ears: Stability
Eyebrows: Medical Support
Eye Size: Safety
Pupil: Electricity
Nose: Infrastructure
Mouth: Education
Lacking parts:
No current (< 4 months) information
Low
Medium
High
CHA AB
EMAM SAHEB
QALA-I-ZAL
RUSTAQ
KWAJA GHAR
DASHTE ARCHI
CHAHAR DARA
KDZ
KHAN ABAD
BANGI
TLQ
KALAFGAN
ALI ABAD
ISHKAMISH
FARKHAR
WARSAJ
Interpret the picture:
• Where is a lack of electricity or water and nutrition?
• What are the most unstable districts?
29


Situational Picture
KUNDUZ & TAHKAR
Education?
Security situation
around KDZ unstable!
Hat: Efficient Governance
Head: Resources (Water/Nutrition)
Symmetry of Ears: Stability
Eyebrows: Medical Support
Eye Size: Safety
Pupil: Electricity
Nose: Infrastructure
Mouth: Education
Lacking parts:
No current (< 4 months) information
Low
Medium
High
EMAM SAHEB
QALA-I-ZAL
CHAHAR DARA
KDZ
DASHTE ARCHI
KHAN ABAD
RUSTAQ
KALFAQAN
TLQ
BANGI
FARKHAR
ISHKAMISH
WARSAJ
Information?
Electricity, Nutrition?
30


District Profile Folder
• Operational Info (J3, J2, MilGeo)
• Key Leader Info (J9, PM)
• Security Situation (J2)
• Civil Situation (J9)
• CJETO Assessment (J2, J9, PM)
NATO/ISAF RESTRICTED
District Assessment
WARSAJ
ISAF
Update: 07.09.07
Allgemeine Informationen
Familien: Ca. 7.446
Einwohner: Ca. 45.000
Männer: Ca. 7.500
Frauen: Ca. 7.500
Kinder: Ca. 30.000
Ethnien: Pa: Ta: 95% Uz: Ha: 5% So:
Gesamtbewertung CJETO
Stand: 03.09.07
Security
Reconstruction & Development
Governance
1A 1B 1E 2B 3B 3C 4A 4B 5B 6A 6B 7C 8A 9A 9B 10A 11B 11D 13C 13E
31

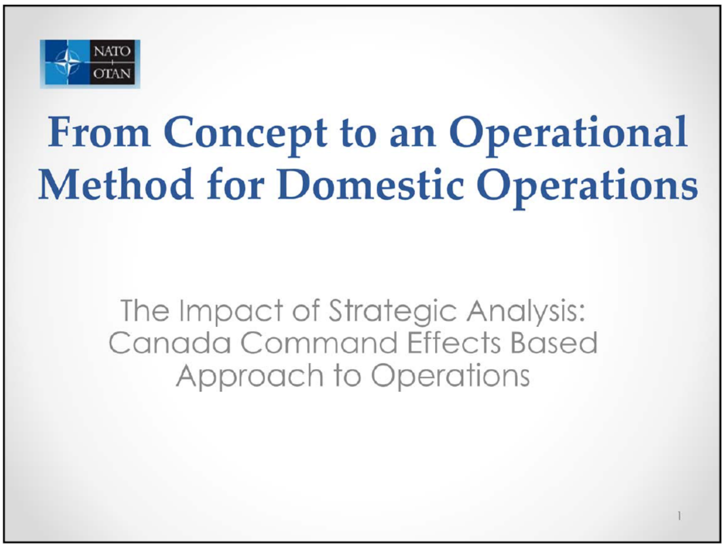
A.3 STRATEGIC PLANNING

A.3.1 Strategic Analysis

INSTRUCTIONAL MODULE SUMMARY

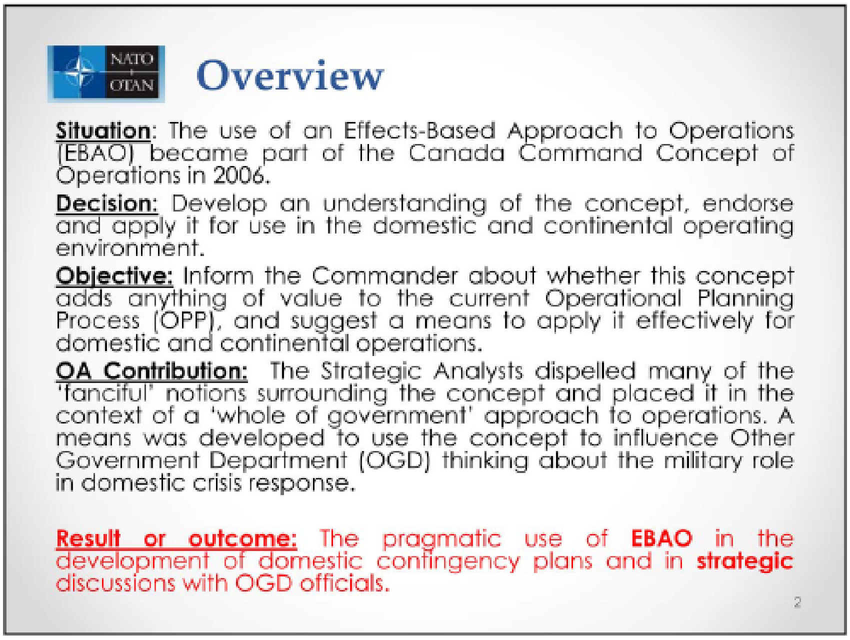
Title	From Concept to Operational Method for Domestic Operations, The Impact of Strategic Analysis: Canada Command Effects-Based Approach to Operations
Faculty Name(s)	Brad Gladman, DRDC CORA, Ottawa ON, Canada
Length	60 – 90 minutes
Learning Objectives	Understand the value of the distinct capability of strategic analysis. Appreciate the relationship of strategic analysis to competent operational planning in achieving the Commander's intent. Appreciate the need for an appropriate reporting relationship, and other essential requirements, in order to realize the potential of strategic analysis in decision-support.
Outcomes	As the result of this module, participants will be able to: Understand the value of the distinct capability of strategic analysis in decision-support. Understand how strategic analysis can complement competent operational planning in the development of a clear operational method, which in this case was used to change other government department thinking about the 'effects' the military can generate in various crises as part of a Whole of Government approach. Understand what strategic analysis requires in order to be successful in any organization it supports.
Content Outline	Case Study: Canada Command Effects-Based Approach to Operations. Vague concept to operational method. Concept tailored to domestic/continental operating environment as part of a Whole of Government approach. Summary of strategic analysis requirements for success in any organization.
Materials	List Required Pre-Readings: Gladman, B. and Archambault, P., "An Effects Based Approach to Operations in the Domestic and Continental Operating Environment: A Case for Pragmatism", Ottawa: DRDC CORA Technical Memorandum 2008-033, 2009.

Methods	50% Lecture 0% Class Exercises. _50% Break Outs.
Exercise(s)	
Break Outs	X Yes ___ No. __#_5__ participants in each break out group.
Discussion Questions	Does your organization have an embedded strategic analysis capability? In your view, does it require such a capability? In your experience, in what instances would your organization have benefitted from strategic analysis for decision-support? How should this capability be structured and how should it report to the senior level of your organization? If this capability did not report to the highest level of your organization, was its impact impaired? If so, how?



The purpose of this presentation is to understand the value of the distinct capability of strategic analysis; appreciate the relationship of strategic analysis to competent operational planning in achieving the Commander's intent; and appreciate the need for an appropriate reporting relationship, and other essential requirements, in order to realize the potential of strategic analysis in decision-support.

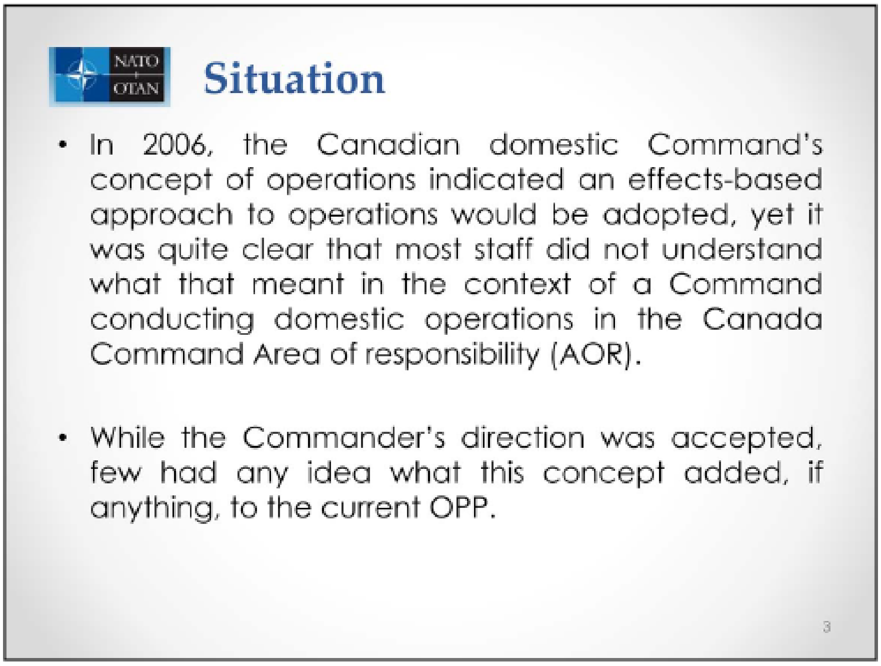
Strategic Analysis is the study of the use of instruments of national power to achieve strategic objectives, with an emphasis on understanding military power. Using methods from Strategic Studies, Social Sciences, History and data from open and classified sources, Strategic Analysts develop strategic outlooks, assessments, case studies, scenarios, military trend analyses, and strategic lessons learned to support and inform strategic decision-making within the Canadian Armed Forces and the Department of National Defence.



In 2005 the Canadian Chief of the Defence Staff initiated an intensive transformation effort built around a series of guiding principles designed to reorganize the command and control of the Canadian Armed Forces to make it more responsive and effective, and thereby more relevant. One of the recommendations made was the establishment of an integrated operational level command responsible for domestic operations, Canada Command.

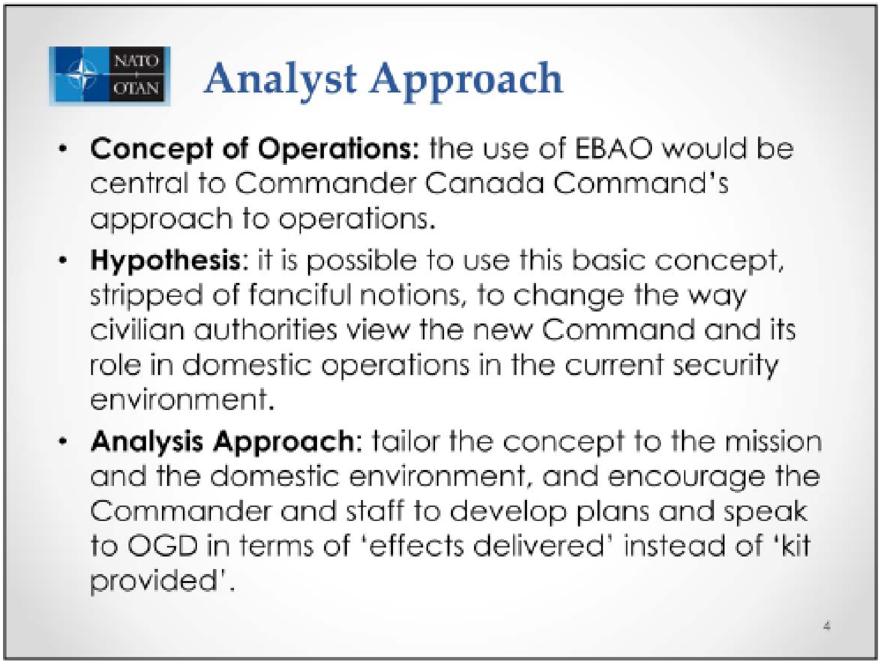
As this command established itself, its first concept of operations indicated it would adopt an effects-based approach to operations.

The strategic analyst's task was to look pragmatically at the concept and find a way to apply it effectively for operations in the Command's area of responsibility. In so doing, the analyst helped to move the command towards an operational method that enhanced strategic discussions with other government department officials.



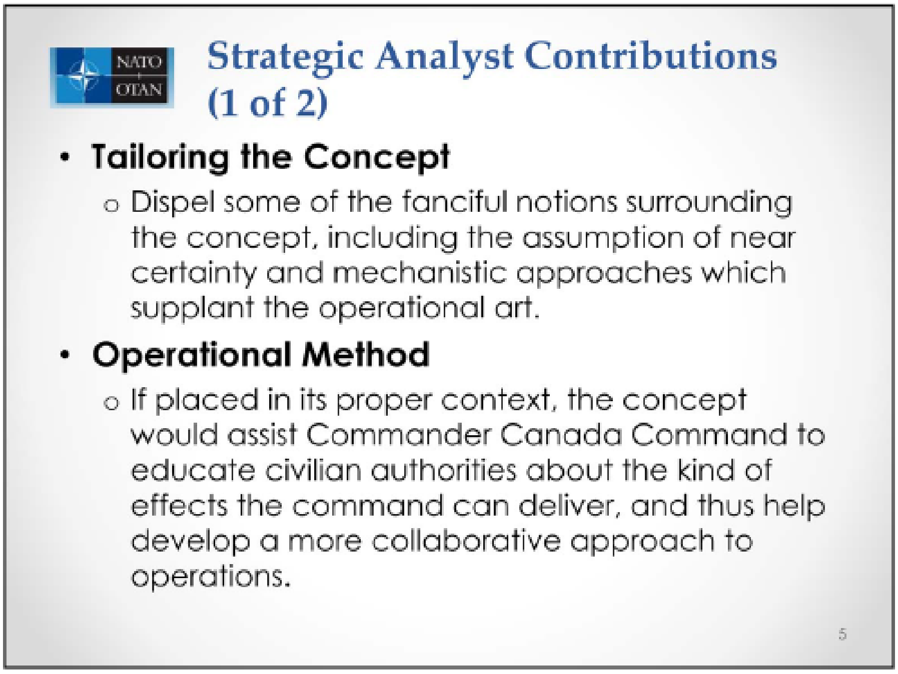
Military operations in Canada and its approaches are, for the most part, in support of other government departments. Excepting defence of Canada and other purely defence missions, the military acts only in support of Provincial or Federal authorities under very specific legal authorities.

At times before the establishment of Canada Command, other government departments and Provincial authorities viewed the military as a warehouse from which to draw equipment and personnel for various purposes. In one instance in 1999 the mayor of Toronto asked for military assistance to shovel snow following a blizzard. Because of the direct reporting relationship of the analysts within the command, the strategic analyst knew the Commander wanted the way OGDs viewed the military to change. The strategic analyst saw the EBAO concept as a possible means to that end.



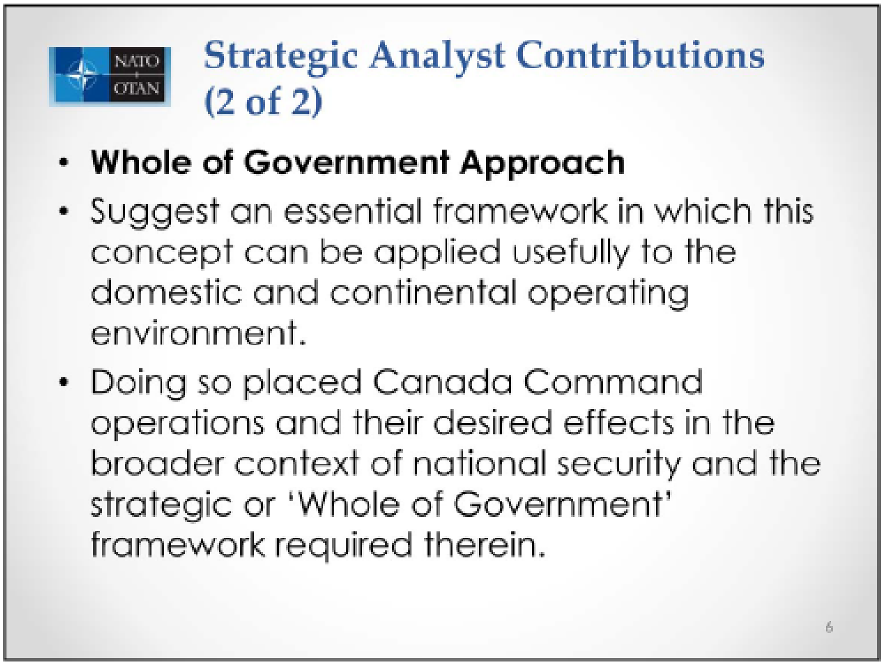
In order to apply this concept towards that end, the strategic analyst examined the effects-based operations concept and tried to tailor it to the realities of military operations in the domestic operating environment. After a great deal of analysis of Allied approaches to this concept, it was determined that the best way forward initially was to suggest that the Commander and staff develop plans and speak to OGD officials in terms of military 'effects delivered' instead of 'kit provided'.

The suggested approach was quite simple, and quite different to the approach typically suggested by effects-based operations concept developers. Its aim was to change how the military's role in domestic contingencies was viewed by civilian authorities.



Before doing so, it was necessary to examine the concept pragmatically and to strip it of its fanciful notions (including its mechanistic approach to operations and the ability to develop and maintain near certainty).

If placed in an appropriate context, the concept could assist Commander Canada Command to educate civilian authorities about the kind of effects the command could deliver, something which would foster a collaborative approach to operations.



In essence, the analyst argued, an effects-based approach allows the military to work within a Whole of Government framework, while providing a language that reflects the military's unique capabilities. And that uniqueness must be protected as a matter of course. It is necessary for the CAF not to civilianize its planning processes.

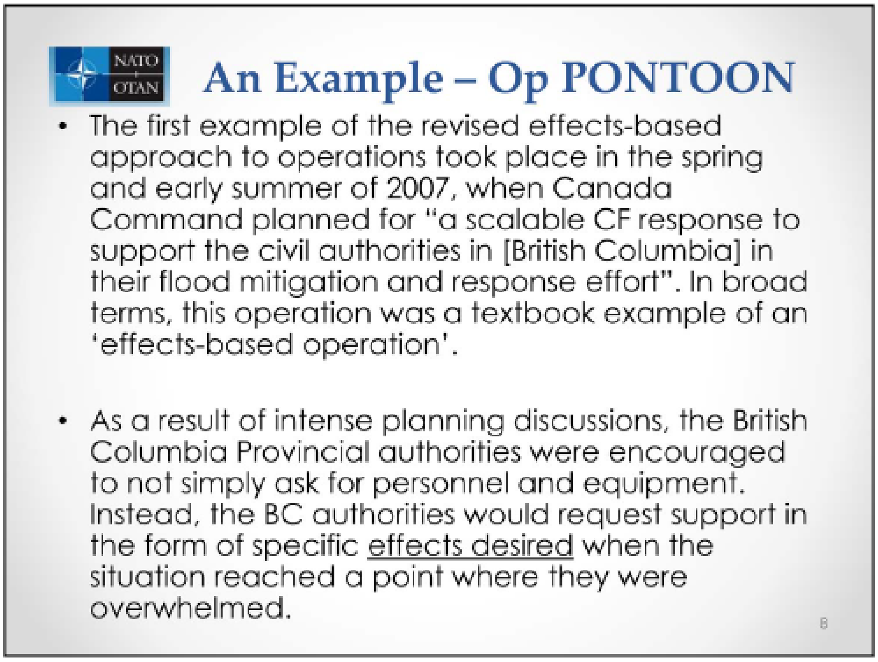
Furthermore, the strategic analyst argued, the military should not drive, or be perceived to be driving, the Whole of Government approach within the domestic context since in most cases the military acts in support of a lead department or Provincial authority. Being the 400 pound gorilla in the room during planning meetings with civilian authorities would not produce a collaborative approach.

For domestic operations, the strategic analyst concluded that EBAO doctrine should not be made more complicated than need be. And really all it needs to be is codified as a pragmatic iteration of best practices identified by operators based on simple guiding principles.

The analysis of the concept led to a general approach to operations that highlighted the military's unique capabilities and 'effects' it could deliver during a crisis response. This differed markedly with the general perception that the military was something to call when you need x number of cots and some trucks and food.

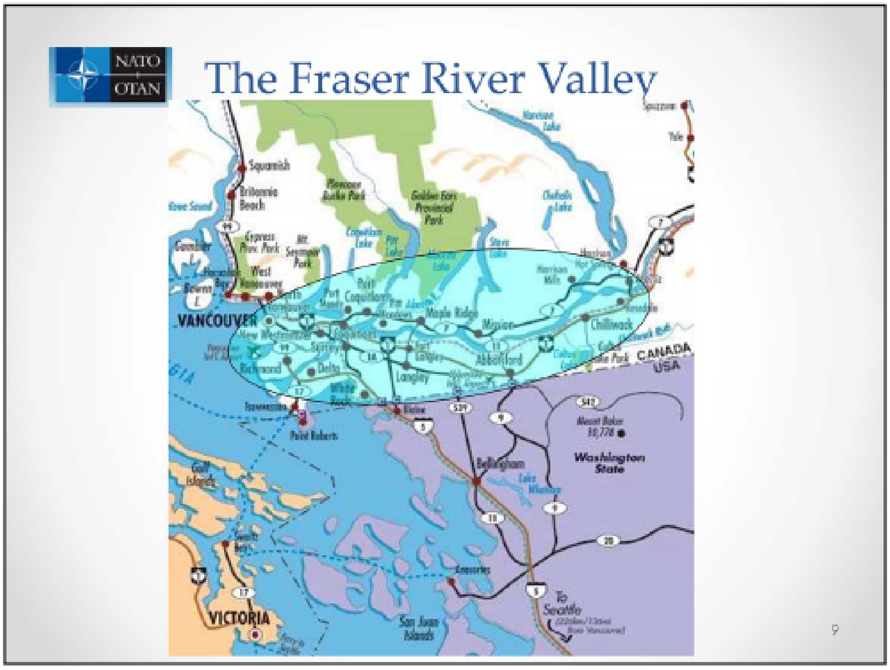
In this instance, the success of this project was due in large part to the strategic analyst having a direct reporting relationship with the Commander, something essential to understand his perspectives on domestic operations and his need to alter how civilian authorities viewed his command and the military in general.

Strategic analysis is a unique form of operational research and analysis, and requires unfiltered access to the top level of whatever organization it is supporting. Without this access, the ability to comprehend fully the true strategic issues is impaired. In this instance, that access produced an operational method that exceeded the Commander's expectations.

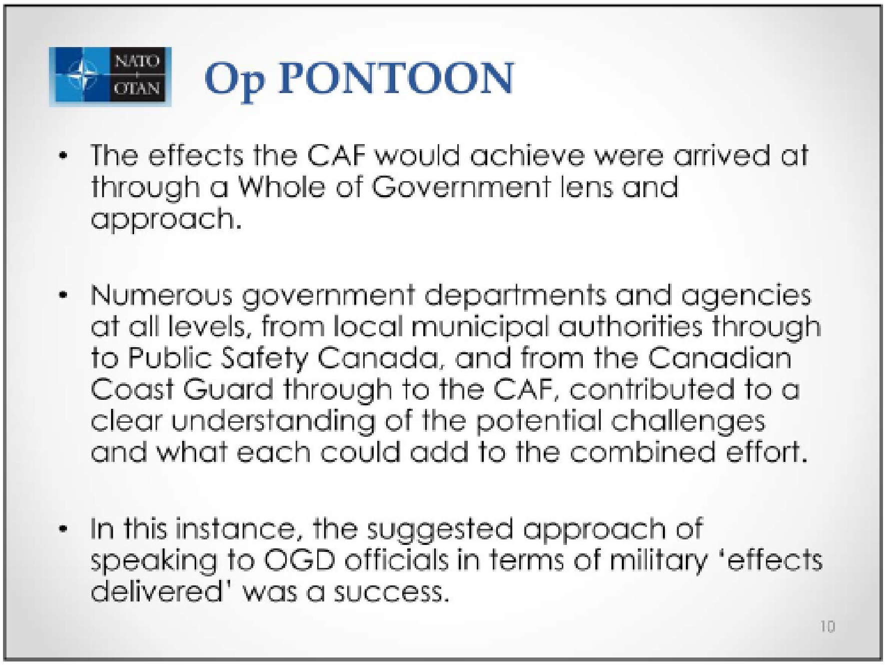


A specific example: Op Pontoon. The Canadian Forces response to the potential flooding of the Fraser River Valley was, in broad terms, a textbook example of an effects-based operation.

In preparing for the operation, the strategic intent of both the British Columbia provincial authorities and the senior leadership of DND/CF, and the expected nature of the CF participation, was clearly spelled-out and nested within the operational orders. Thus, the operational level planning was synchronised with the desired strategic end-state, as was the tactical planning.



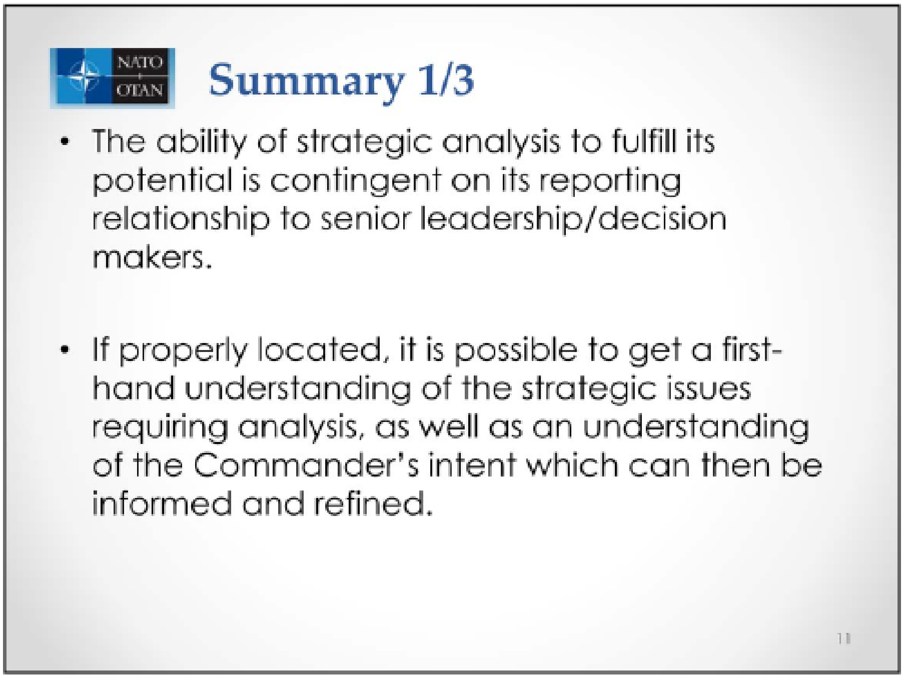
This is an image of the Fraser River Valley, along which are a number of large urban centres including one of the largest cities in Canada, Vancouver. The potential impact of large-scale flooding along this river is easy to envisage, as is the potential for overwhelming local and provincial authorities.



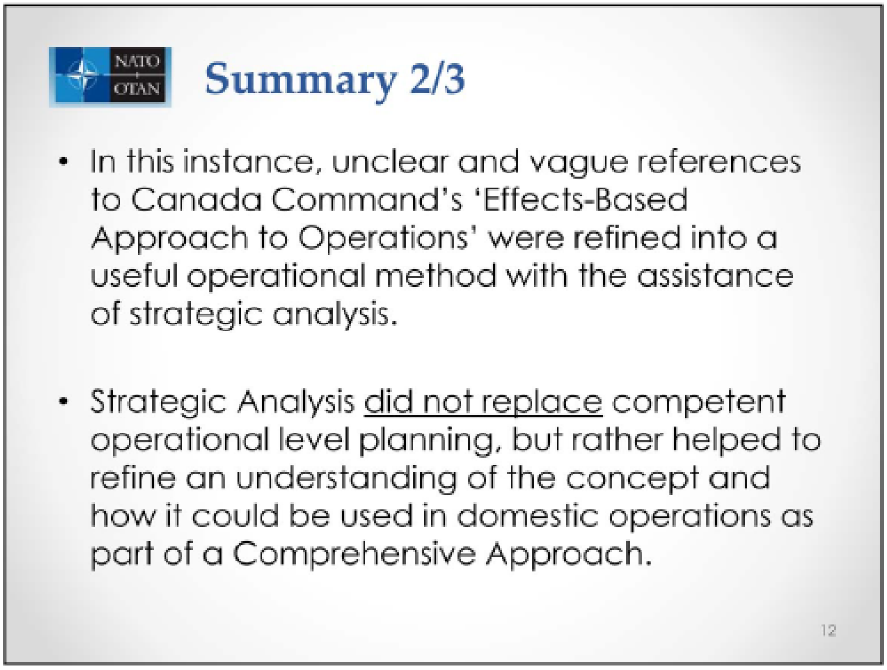
Various government departments and agencies from the local municipal authorities through to federal authorities including Public Safety Canada, the Canadian Coast Guard and the CAF contributed to a clear understanding of the situation and what each could add to the combined 'whole of government' effort. It marked a substantial change in approach and how the other departments viewed Canada Command and what it could provide.

In this instance, the flooding was not as damaging as anticipated, and yet Canada Command planners had prepared a phased response tied to a series of water level indicators developed in collaboration with civilian authorities. The military was in a position to provide its unique effects in a timely fashion if required, and the strategic relationship between Canada Command and its supported partners was clearly understood and appreciated.

The main contribution of the strategic analyst in this effort was to help shape the Command's approach to such operations, something which enhanced operational planning and in changing how civilian authorities regarded the military. The success of this effort and the analyst's role had certain requirements.

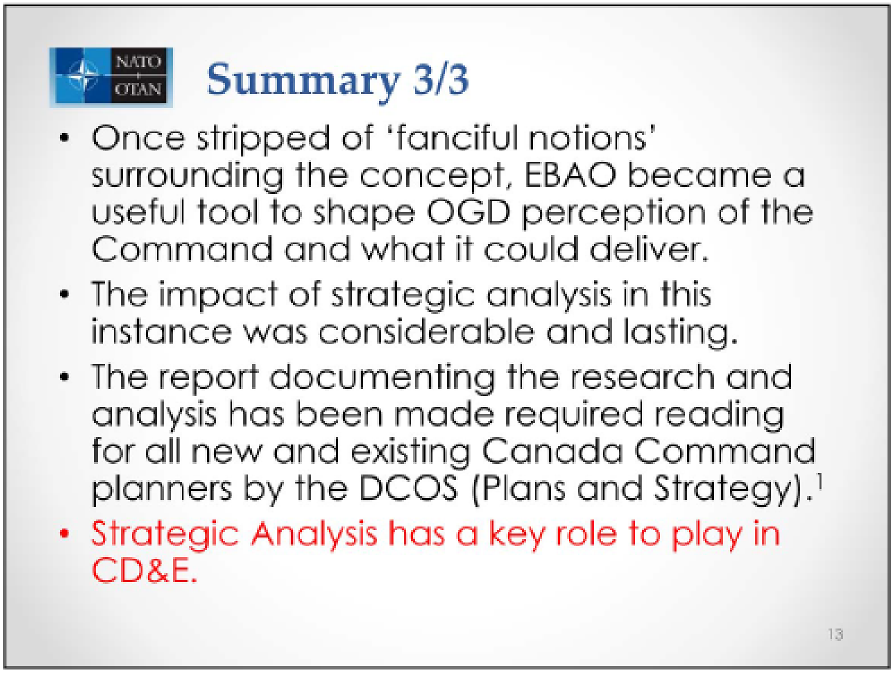


First, the strategic analyst had to report directly to senior leadership. That relationship enabled an understanding of the truly strategic issues requiring analysis, as well as an understanding of the Commander's intent which can then be informed and refined. The more levels in the way and the more filters through which the analyst has to speak can seriously degrade the ability to provide effective strategic analysis.



In this instance, and due in large part because of the direct reporting relationship and personal credibility, an initial uncertainty about how to apply an Effects-Based Approach to Operations from the Commander's Concept of Operations was refined with the assistance of strategic analysis into a useful operational method.

Strategic Analysis did not replace competent operational level planning, but rather enhanced it.



Once stripped of the more 'fanciful notions' surrounding the concept, an effects-based approach to operations became a useful tool to shape the perception of Canada Command and its role in this kind of domestic operation.

Because of the close working relationship between strategic analysis and the Commander, the effect was considerable and lasting. The report documenting the research and analysis leading to the recommended operational method was made required reading for all Canada Command planners.

Endnotes

1 Brad Gladman and Peter Archambault, *An Effects Based Approach to Operations in the Domestic and Continental Operating Environment: A Case for Pragmatism* (Ottawa: DRDC CORA Technical Memorandum 2008-033, 2009).

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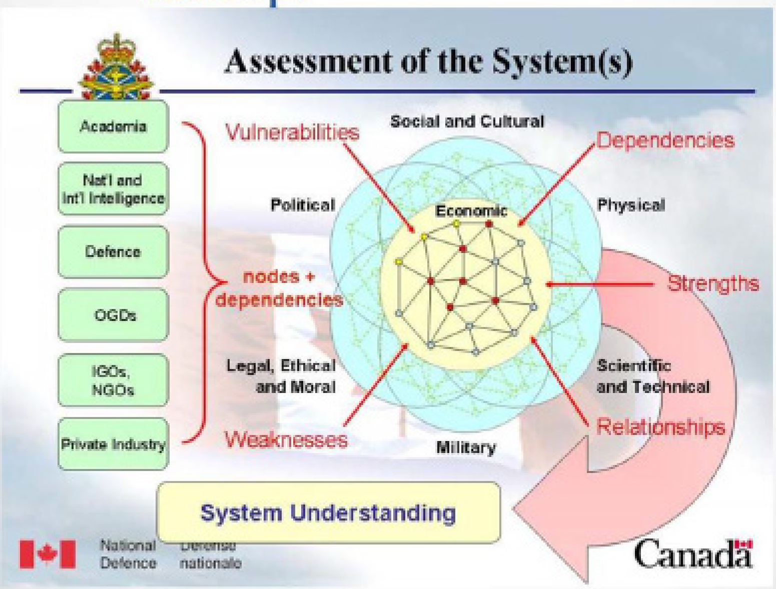
Unhelpful Approaches to the Concept



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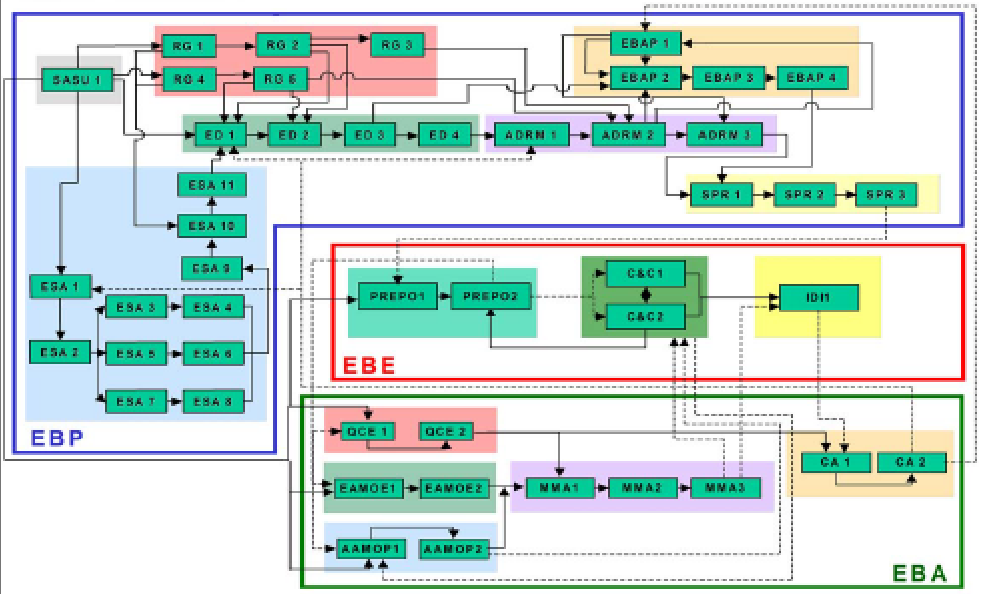
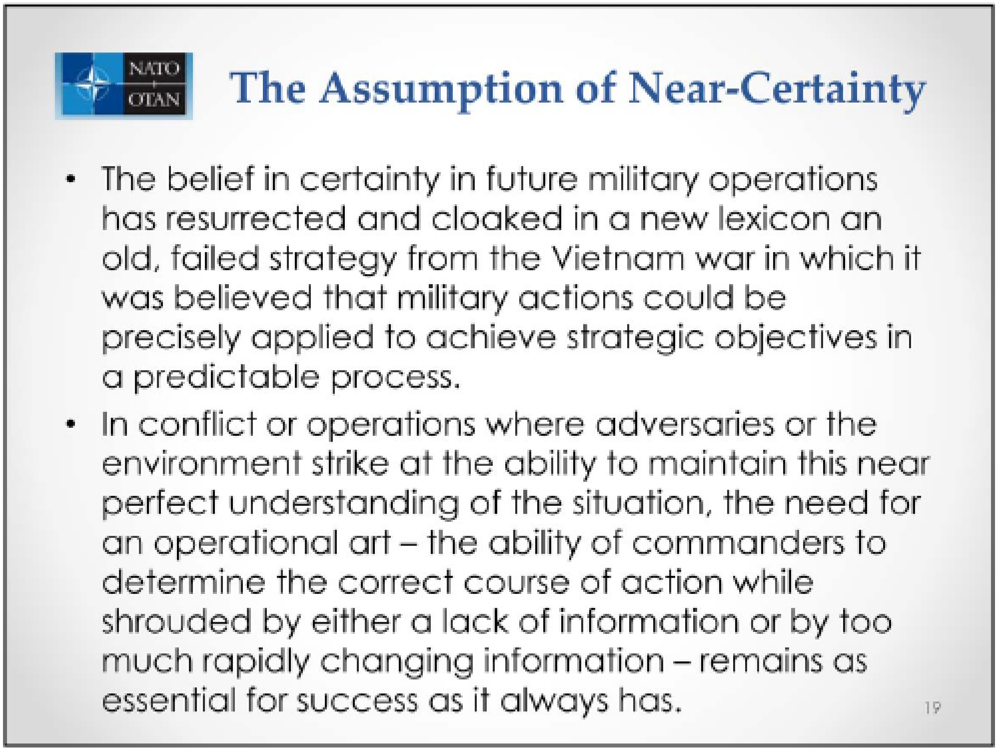
Whither the Operational Art?

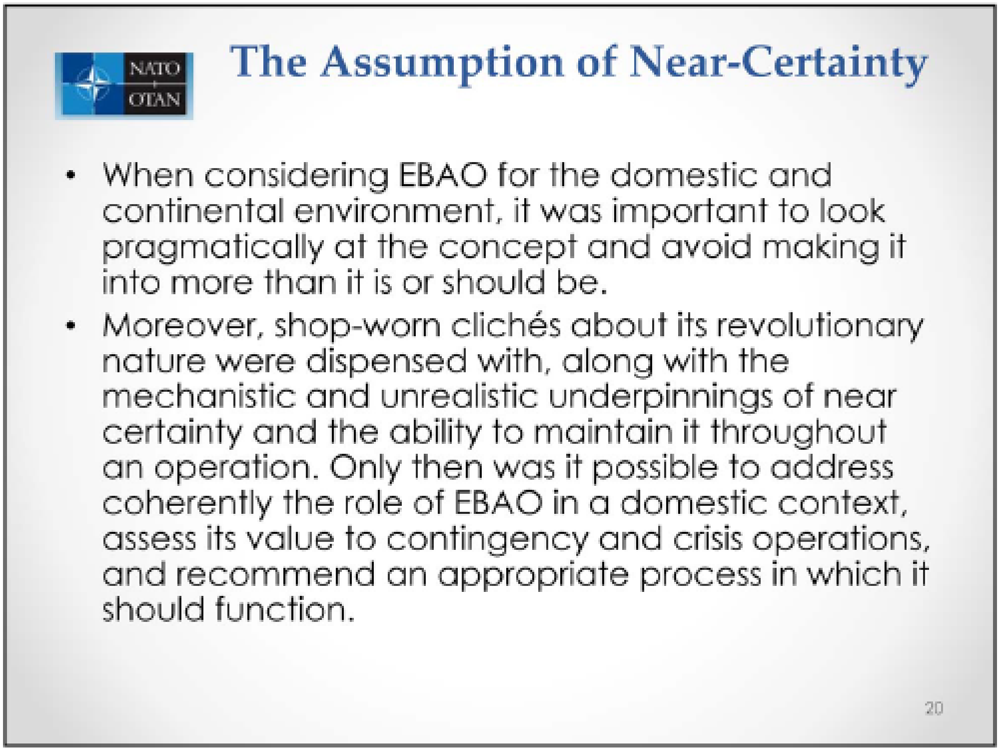


Cracks in the Foundation

- Some proponents of EBAO have argued its revolutionary nature and discontinuous departure from past operational methods, but in fact the principles underlying the concept are not new. The best military commanders and the most capable statesmen always have focused on attaining the desired end state and did not discount the human dimension of conflict. They routinely mobilised all elements of national power to attain the desired end-state.
- While technological advances have impacted operations across the spectrum of conflict, they have not eliminated many of the problems encountered in operations, or so revolutionised the approach to the military art that past experience is no longer relevant.

18





A.3.2 Peace Support and Game Theory

(see Application Area 1 – Section A.2.4)

VOLUME 2

A.4 TRANSFORMATION

A.4.1 Base Realignment and Closure

INSTRUCTIONAL MODULE SUMMARY

Title	U.S. Army Base Realignment and Closure (BRAC) Using Military Value Analysis
Faculty Name(s)	Dr. Lee Ewing, Naval Postgraduate School, Monterey, California, USA
Length	20 – 30 minutes
Learning Objectives	Understand the use of operational research techniques to logically assess both the qualitative and quantitative aspects of value analysis. Gain an appreciation for the relationship is strategic level resource decision-making and creating analytical objectives to support that decision.
Outcomes	As the result of this module, participants will be able to: Appreciate the ability to assess alternatives in a strategic resource decision both qualitatively and quantitatively. Understand the contribution of decision analysis techniques to aid in decision-making.
Content Outline	Case Study: BRAC decision. Mapping Value to alternatives in the decision process. Creating two-dimensional value matrix. Creating an objective function for multiple optimization problems.
Materials	List Required Pre-Readings: None.
Methods	80% Lecture 20% Class discussion. ____% Break Outs.
Exercise(s)	None.
Break Outs	___ Yes X No. __#___ participants in each break out group.
Discussion Questions	In your experience, where has value mapping been used to aid decision-making?

Army Base Realignment and Closure (BRAC) 2005 Military Value Analysis

A Case Study using Decision Analysis

13.01.18 1

Overview

Situation: WHAT IS BRAC? A process the Services use to reduce infrastructure and operating costs in a politically sensitive environment

Decision: As mandated by the BRAC law, determine the military value of an Army installation.

Objective: Develop the Army's BRAC position which provides the maximum military value.

OA Contribution: Provided an auditable, repeatable, and defendable approach that supported Army/DoD decision makers resulting in a 95% Presidential Commission approval rating for the Army (vs. 85% overall)

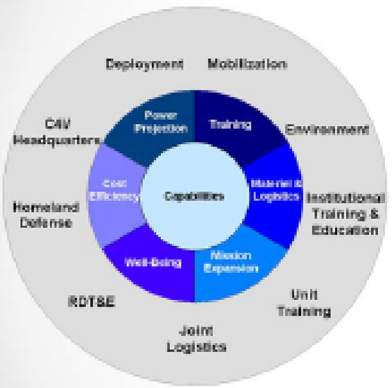
Result or outcome: A two year study that resulted in a $50 Billion program, involving US Armed Forces, millions of people, hundreds of locations, oversees forces, soldiers and their families

12.08.12 2

Approach

- The Qualitative Aspect
  - Informed by 36 senior leader interviews, numerous staff interactions, and an extensive literature review
  - Consists of six primary competing objectives and 40 supporting attributes
  - Forms the framework for the quantitative analysis
- The Quantitative Aspect
  - Quantitative functions are defined by the qualitative attributes which directly support previously defined objectives
  - Subjective nature of weighting is reduced

Analysis Objectives and Supporting Measures



....all mapped to Congressional military value criteria

Capabilities			Value Measures
Support Army and Joint Training Transformation	Maneuver Space / Air Space		Airspace
		Maneuver Space	Heavy Maneuver Area
			Light Maneuver Area
	Impact Area and Ranges		Direct Fire Capability
			Indirect Fire Capability
			MOUT Capabilities
	Environmental Impact on Training		Soil Resiliency
			Noise Contours
			Air Quality
	Institutional Training		Applied Instructional Facilities
			General Instructional Facilities
Maintain Future Joint Stationing Options	Mission Expansion		Brigade Capacity
			Buildable Acres
	Mission Expansion Factors		Critical facility proximity
			Urban Sprawl
			Environmental Elasticity
			Water Quantity
Power Projection for Joint Operations	Power Projection		Force Deployment
			Materiel Deployment
			Mobilization
	C2/Admin		Accessibility
			Connectivity
			Operations / Administrative Facilities
Support Army Materiel and Joint Logistics	Support Joint Logistics		Supply and Storage Capacity
		Maintenance Production	InterService/Partnering Workload Flexibility
			Maintenance / Manufacturing Capability
		Munitions	Munitions Production Capability
			Ammunition Storage Capacity
	RDT&E		Test Range Capability
			RDT&E Mission Diversity
Achieve Cost Efficient Installations			Workforce Availability
	Installation / Facilities		Area Cost Factor
			Joint Facilities Cost Sharing
			Installation/Unit Cost Factor
			C2 Target Focus Facilities
Enhance Soldier and Family Well-Being			In-State College Tuition Policies
	Local Community		Crime Index
			Housing Availability
			Employment Opportunity
			Medical Care Availability

OA Contribution

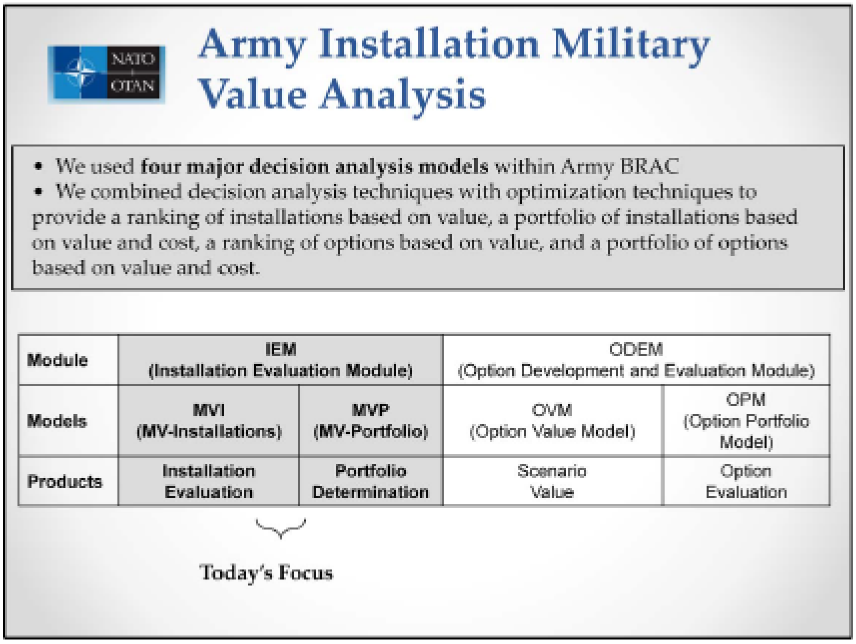
- Supported major Army decisions to enable dramatic cost savings.
- Army BRAC submissions had a 95% Presidential Commission approval rate (85% overall).
  - Results are auditable and repeatable because the process is well documented and not a "black box"
  - Analysis is accepted because it is qualitatively and quantitatively defendable
- OA analysts made two important technical contributions
  - Swing Weight Matrix
  - 2-Dimensional value measures

5

Summary

- Decision Analysis is appropriate for strategic and operational decisions which are characterized by competing objectives
- Provides *vision* on a way forward for difficult policy issues
- Very powerful technique to determine the objective function for multiple objective optimization problems

6



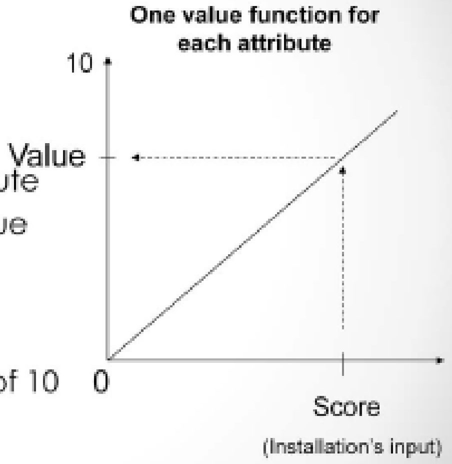
1. The current and future mission capabilities and the impact on **operational readiness** of the Department of Defense's total force, including impact on joint warfighting, training, and readiness.
2. The availability and condition of **land, facilities** and associated airspace (including training areas suitable for maneuver by ground, naval, or air forces throughout a diversity of climate and terrain areas and staging areas for the use of the Armed Forces in homeland defense missions) at both existing and potential receiving locations.
3. The ability to accommodate **contingency**, mobilization, and future requirements at both existing and potential receiving locations to support operations and training.
4. The **cost** of operations and the **manpower** implications.

Certified data and many studies required to support the MV decision analysis

Attribute (#)	Supporting Office
Soil Resiliency (11)	Army Environmental Center (AEC)
Deployment (14, 15)	Military Surface Deployment and Distribution Command, Transportation Engineering Agency (TEA)
Accessibility (17)	Center for Army Analysis (CAA)
Connectivity (18)	Army G-6
Work Force Availability (31)	Office of Economic and Manpower Analysis at West Point (OEMA)
Environmental Elasticity (38)	Army Environmental Policy Institute (AEPI)
Urban Sprawl (39)	Construction Engineering Research Laboratory (CERL)
Critical Infrastructure Proximity (40)	CAA
Other Papers: Climate & Terrain Analysis Staging Area Analysis	TABS and ACSIM (GIS Group)

Military Value Calculation

- Process steps include
  - Select Attribute$_i$ (A_i)
  - Select Weight$_i$ (w_i)
- To calculate MV
  - Find the score for an attribute
  - Convert the score to a value
  - Sum the weight of each attribute multiplied by the value for each attribute
  - $MV_i = \Sigma_i\, w_i\, V(A_i)$, max MV of 10



Two Dimensional Constructed Measures

	TOTAL HVY MVR AREA (1000s acres)			
Largest Contiguous Area (1000s acres)	<=10	>10 and <=50	>50 and <= 100	>100
< = 10	0.1	0.2	1.3	2.0
>10 and < = 50	X	3.2	4.2	5.1
>50 and < = 100	X	X	6.1	7.6
>100	X	X	X	10.0

- Captures complex dependencies relationships
- Still allows us to use additive value model

Benefits

Captures the value dependence between several attributes

Captures qualitative and quantitative measures in one attribute

Matrix offers visual perspective and SME's more comfortable with value assessments

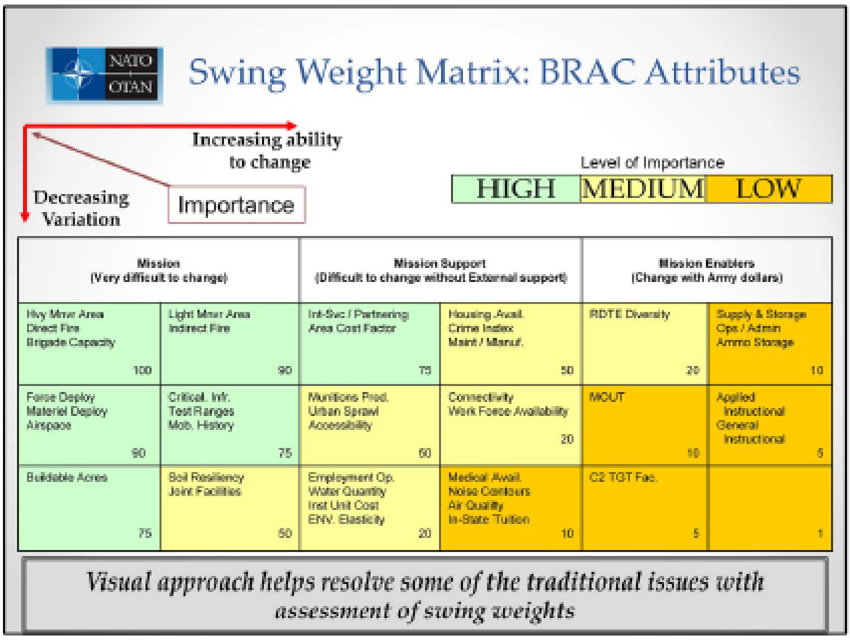
Results in fewer attributes in MODA

Limitations

Difficult to develop and harder to assess than natural scales

What measures (bins) are appropriate?

Must be consistent when evaluating SME preferences



Driven by the need to explain rationale for the weights to auditors and BRAC Commission

Difficult to gain consensus with a "group" of decision makers

- Subjectivity issues
- Inherent preferences

Considered existing assessment techniques

- Swing weights
- Pair-wise comparisons

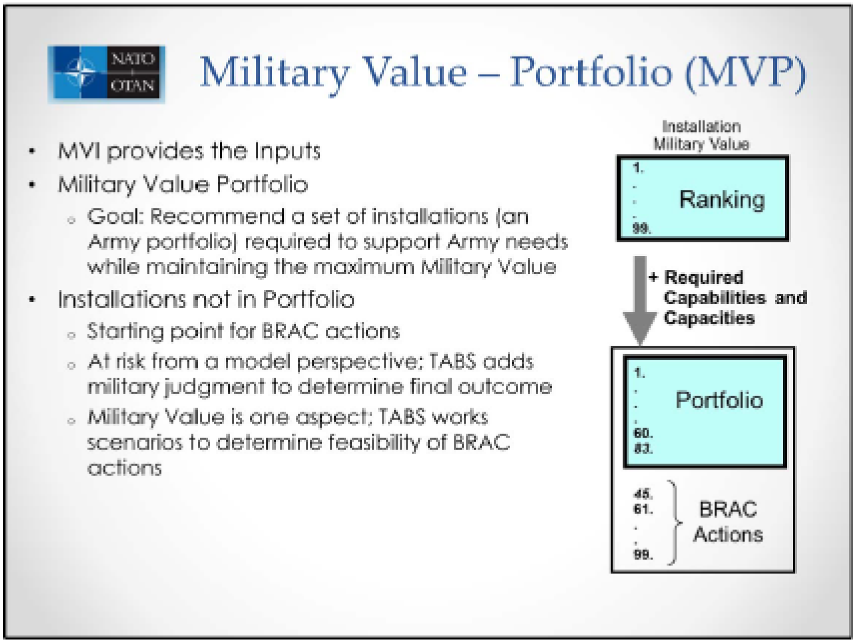
Benefits

Visually depicts importance and variation dimensions of the problem

Provides framework for consistent swing weight assessments

Provides auditable weighting rationale that can be explained to senior leadership

Limitations: Requires some professional judgment



Benefits

Captures the value dependence between several attributes

Captures qualitative and quantitative measures in one attribute

Matrix offers visual perspective and SME's more comfortable with value assessments

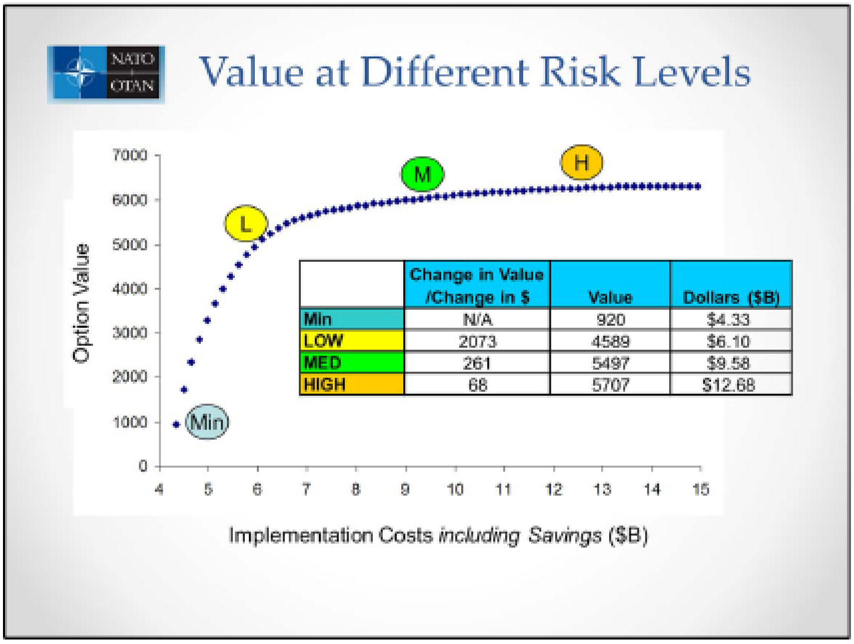
Results in fewer attributes in MODA

Limitations

Difficult to develop and harder to assess than natural scales

What measures (bins) are appropriate?

Must be consistent when evaluating SME preferences

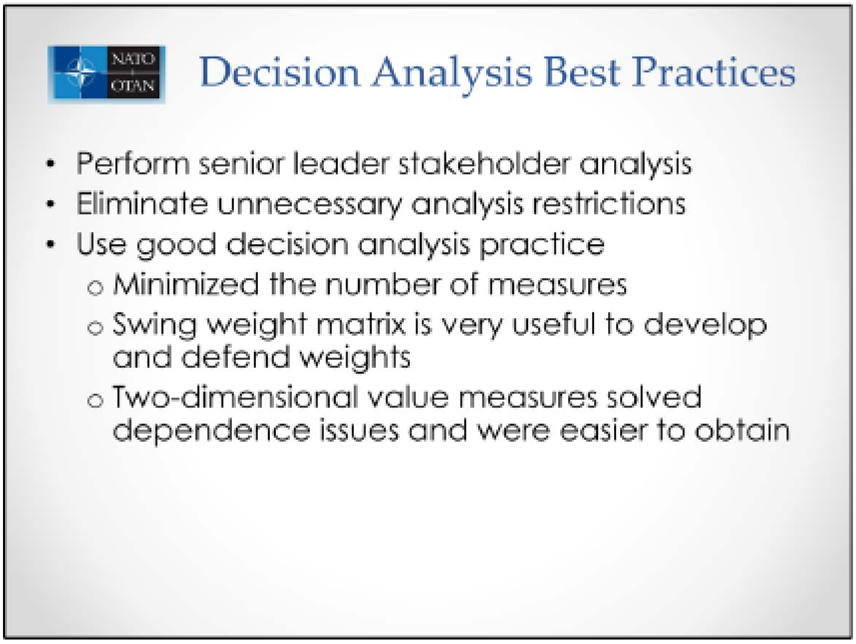


Benefits

- Captures the value dependence between several attributes
- Captures qualitative and quantitative measures in one attribute
- Matrix offers visual perspective and SME's more comfortable with value assessments
- Results in fewer attributes in MODA

Limitations

- Difficult to develop and harder to assess than natural scales
  - What measures (bins) are appropriate?
- Must be consistent when evaluating SME preferences



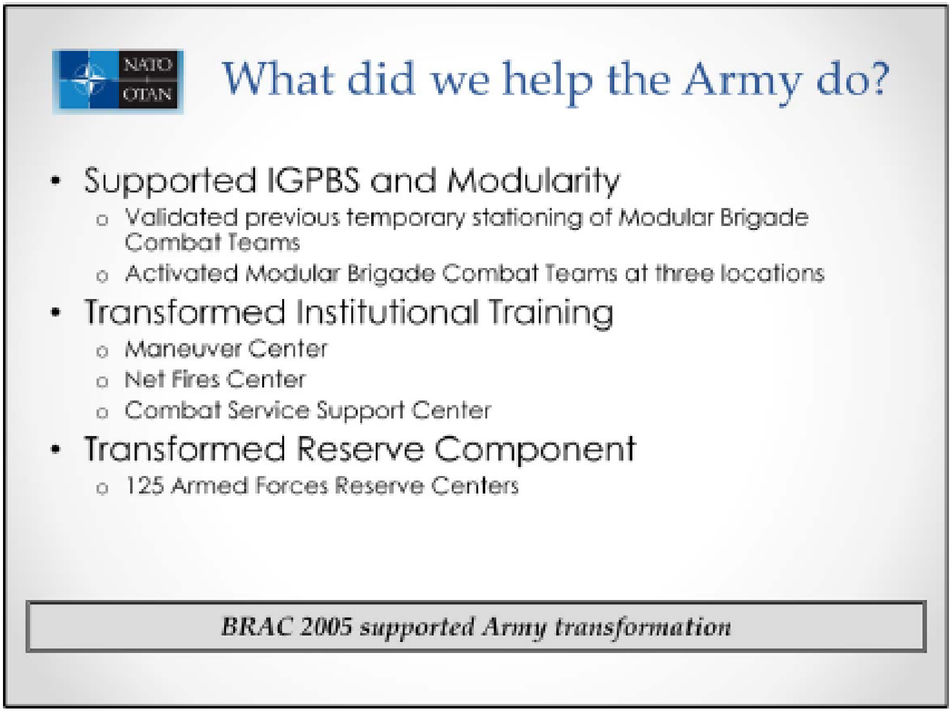
Be prepared. The Army analysis team had significant experience in the problem domain (Army stationing and BRAC) and extensive experience performing operations research and decision analysis for senior leaders.

Perform senior leader stakeholder analysis. The Army senior leader interviews provided important perspectives, helped identify transformation opportunities, and enabled later access to key subject matter experts to help develop models.

Eliminate unnecessary constraints. Unlike BRAC 1995, we removed the installation category constraint. This allowed us to consider the military value of an installation for any Army mission. This increased the solution space by allowing possible alternatives that moved missions between installation categories.

Use good decision analysis practice. Use an appropriate technique. First, we minimized the number of attributes. This meant we could obtain high quality data for fewer high quality measures. Second, the two-dimensional measures addressed the value dependence problem and helped gain senior leader support. Finally, the Swing Weight Matrix was very useful to assess, explain, and defend weights.

Ignore bad advice. We received three recommendations that we did not follow. First, during our initial assessment, some individuals who had worked BRAC 1995 warned us not to change the successful BRAC 1995 process. We viewed BRAC 2005 as fundamentally different due to the emphasis on transformation and joint warfighting. Secondly, some thought it was a very bad idea to interview senior leaders. This was easy advice to ignore. Finally, some of our friends warned us not to “waste our time working on a process that was only politics.” We viewed the opportunity to help the Army transform and save resources in a time of war, as well worth the professional and personal risk.


What did we help the Army do?
Supported IGPBS and Modularity
Validated previous temporary stationing of Modular Brigade Combat Teams
Activated Modular Brigade Combat Teams at three locations
Transformed Institutional Training
Maneuver Center
Net Fires Center
Combat Service Support Center
Transformed Reserve Component
125 Armed Forces Reserve Centers
BRAC 2005 supported Army transformation

A.5 LOGISTICS AND ACQUISITION

A.5.1 Cost Estimating for Major Acquisitions

INSTRUCTIONAL MODULE SUMMARY

Title	Cost Estimation for Major Defence Systems Acquisitions
Faculty Name(s)	Han de Nijs, ACT, NATO
Length	20 – 30 minutes
Learning Objectives	Understand the use of hierarchical clustering and decision trees to effectively forecast costs.
Outcomes	As the result of this module, participants will be able to: Appreciate the OA tools available to forecast costs. Understand the hierarchical clustering of costs of similar ships and use of decision trees to estimate costs for typical configurations.
Content Outline	Case Study: The Netherland's Landing Platform Dock (LPD) ships. Data sample and normalization process viewed through OA lens. Application of decision trees. Ex-post comparison of analysis results.
Materials	List Required Pre-Readings: None.
Methods	80% Lecture 20% Class discussion. ____% Break Outs.
Exercise(s)	None.
Break Outs	___ Yes X No. __#___ participants in each break out group.
Discussion Questions	In your experience, where has hierarchical clustering of costs and use of decision trees been used to estimate costs?

Cost Estimation for Major Defence Systems Acquisitions

Hierarchical Clustering and Decision Trees

Han de Nijs
ACT

Draft for SAS-098, RTG-043 7/9/2013 1

Overview

1. **Situation:** Uncertainty of Cost Estimates for a Major Defence Investment: Landing Platform Dock (LPD)
2. **Decision:** Gathering Cost Data from Other Nations
3. **Objective:** Forecasting Costs
4. **OA Contribution:** Hierarchical Clustering of Costs of Similar Ships and use of Decision Trees to estimate costs for typical configurations

Draft for SAS-098, RTG-043 7/9/2013 2

Background

- The Netherlands' Landing Platform Dock (LPD) ships:
  - Rotterdam L800
    - Commissioned 1997
  - Johan de Witt L801
    - Commissioned 2000

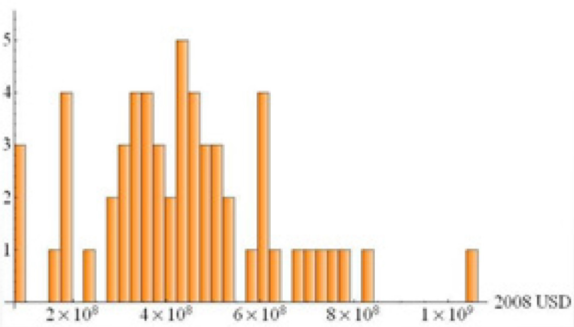
Data Sample

- Database of descriptive, technical, and cost information on 57 ships in 16 classes from 6 nations:
  - Raleigh (LPD, USA) - Mistral (AAS, France)
  - Thomaston (LSD, USA) - Austin (LPD, USA)
  - Anchorage (LSD, USA) - Protecteur (AOR, Canada)
  - Whidbey Island (LSD, USA) - Albion (LPD, UK)
  - Largs Bay (LSD, UK) - Ocean (LPH, UK)
  - plus other 'single-ship' classes
- Sample of the 136 technical attributes collected per ship:
  - Vessel type, dimensions (e.g., length, beam), performance (e.g., speed, range), manning, propulsion and power generation, lift capacity (e.g., well deck, cargo space, cranes, elevators), flight deck, armament and countermeasures, data systems (radar, sonar, etc.), ...
  - Both numeric and nominal attributes
  - Any missing data was replaced with data element's average for known ships
  - Principal component analysis reveals that the data set can be mapped to a 15-dimensional space (accounting for 95% of variance in original data)

Data Normalization

- Cost data:
  - Original data in various currencies and base years
  - U.S. data normalized using historical index for shipbuilding inflation
  - Non-U.S. data normalized using Eurostat indices
  - Fictitious "notional common currency" (NCC)

Histogram of Costs in NATO 076 Ship Database



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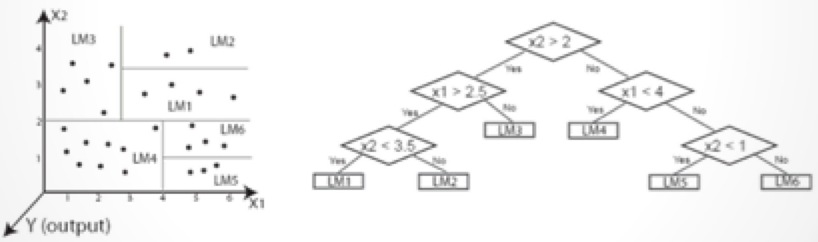
OA Contribution

- The spread of the normalized cost was too wide
- Actual configurations of the ships differed
- Hypothesis: costs depend on configuration
- Solution: construct a decision tree

Footer Text 7/9/2013 • 6

Methodology: Decision Trees

- Statistical Decision Trees
  - Combine decision trees and linear regression
    - Each node or leaf is an estimated multiple linear regression equation
    - First-ever application in defense cost analysis of acquisition programs



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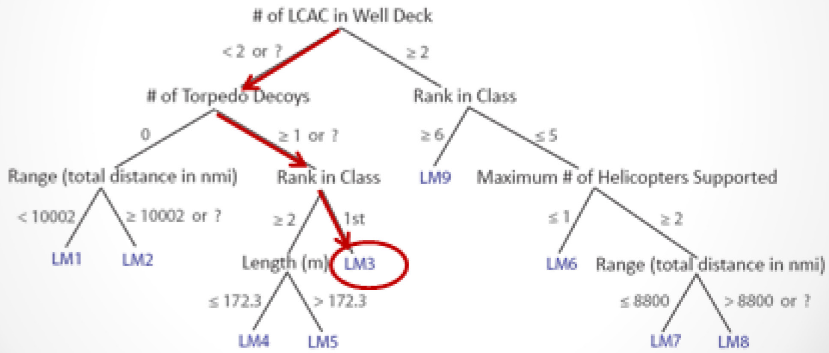
Methodology: Decision Trees

- Applied to Rotterdam and Johan de Witt ships
  - Each regarded as separate ship class by Royal Netherlands Navy
  - Each follow same path



LCAC: Landing Craft Air Cushion

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Methodology: Decision Trees

- Applied to Rotterdam and Johan de Witt ships

LM3

		Rotterdam	Johan de Witt
Log(Cost) =	7.6222		
	- 0.0167 × rank in class	1	1
	+ 0.0041 × length (m)	162.2m	175.35m
	- 0.0002 × range (sailing time in hrs)	500 hrs	833 hrs
	+ 0.0445 × # of LCAC in well deck	0	0
	+ 0.0659 × # of torpedo decoys	1	1

Cost estimates:

Rotterdam L800:	197.7M NCC
Johan de Witt L801:	212.3M NCC

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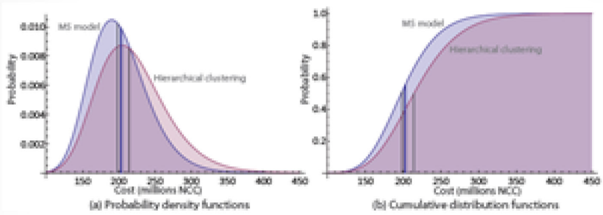
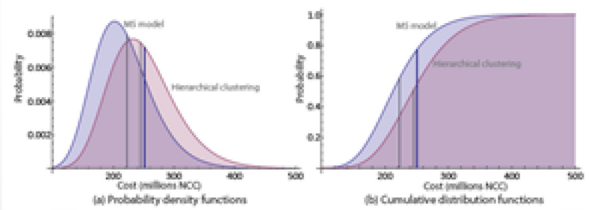
Results: Ex-Post Comparisons

- Rotterdam LPD estimated cost and actual cost



- Johan de Witt LPD estimated cost and actual cost



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A.5.2 Replenishment at Sea Scheduling

INSTRUCTIONAL MODULE SUMMARY

Title	Replenishment at Sea Planner: A Study in Applied Optimization
Faculty Name(s)	Jeff Kline, Naval Postgraduate School, Monterey, California, USA
Length	60 – 90 minutes
Learning Objectives	Understand the concept of optimization. Appreciate the strengths and weakness of optimization. Understand through case example the use of optimization in logistics scheduling.
Outcomes	As the result of this module, participants will be able to: Appreciate the uses of optimization in logistics scheduling.
Content Outline	Case Study: Replenishment at Sea Planner. Optimization Defined. RASP discussed. Case Study: Force structure analysis.
Materials	List Required Pre-Readings: None.
Methods	100% Lecture 0% Class Exercises. _____ % Break Outs.
Exercise(s)	Seminar participants will be asked to evaluate charts and outputs from each case study.
Break Outs	___ Yes X No. __#___ participants in each break out group.
Discussion Questions	What are your experiences with manual scheduling? How might optimization improve that process?

Using Operations Analysis to Schedule Naval Logistics Ships

A Case Study in Optimization

Overview

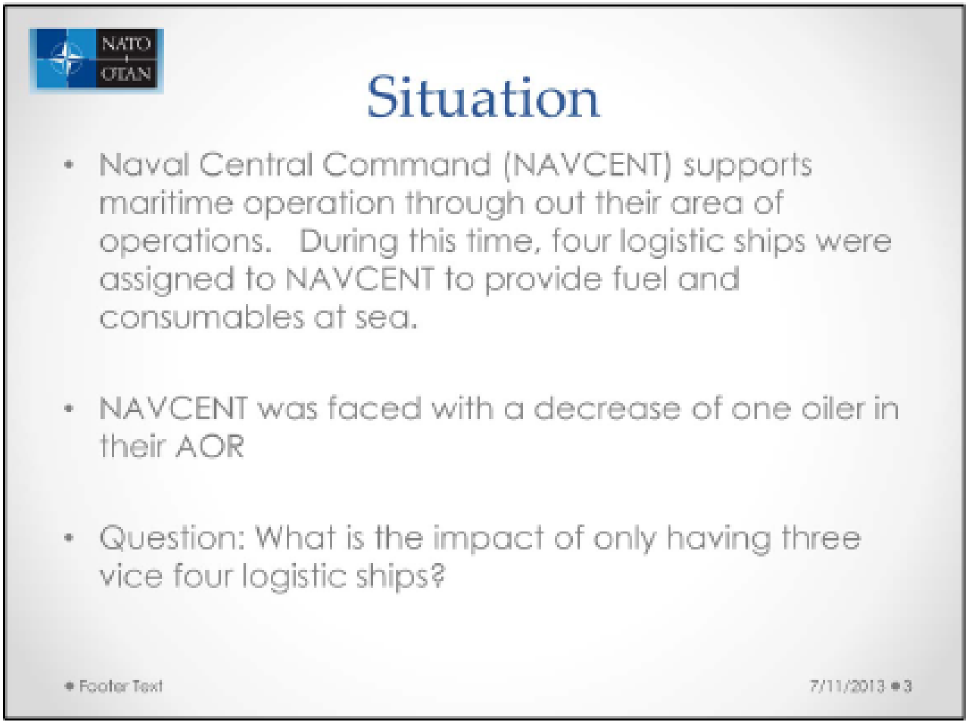
Situation: In 2011 the U.S. Central Command's Naval Commander was faced with losing one of four combat logistics force ships (T-AO) to support theater operations.

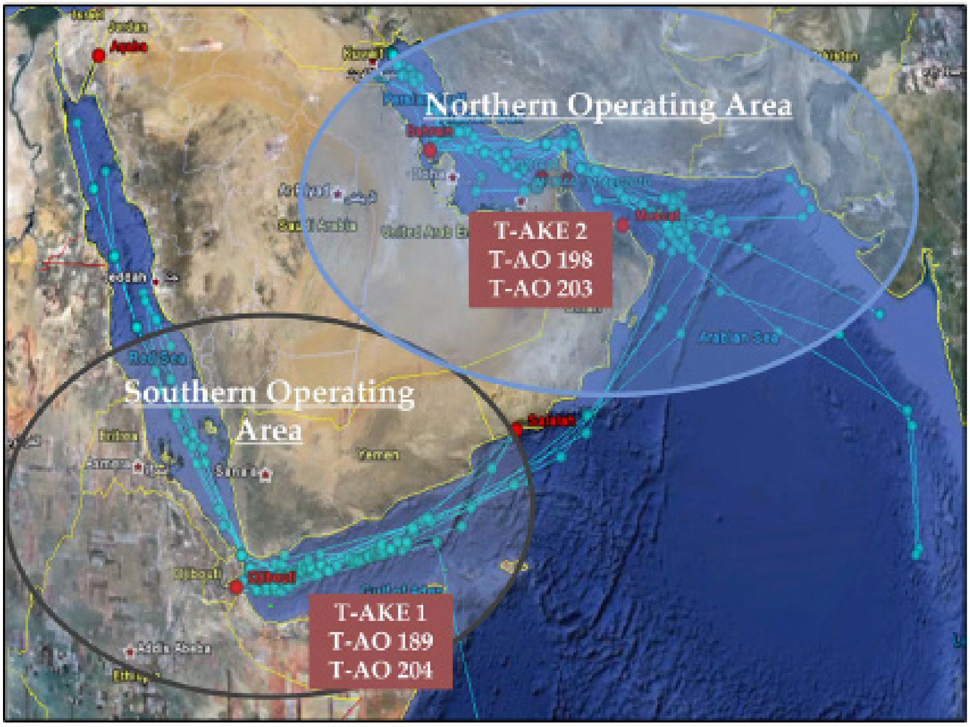
Decision: Would the loss of a logistics ship require change of schedules for the operational forces and/or the other combat logistics force ships?

Objective: Consume the loss of a logistics ship while minimizing impact on operations and other logistics ships schedules.

OA Contribution: Used a scheduling model to determine that the loss of one combat logistics force ship would not impact operations and to minimize impact on logistics ship requirements to use higher speeds to meet fleet demand.

7/12/2013





Defining the areas of interest:
NORTH (Arabian Gulf and Gulf of Oman)
SOUTH (Gulf of Aden, Horn of Africa, Red Sea)
Demarcation point: Salalah, Oman
Blue dots: USS ship movements as provided by OPREP-5 FEEDER data

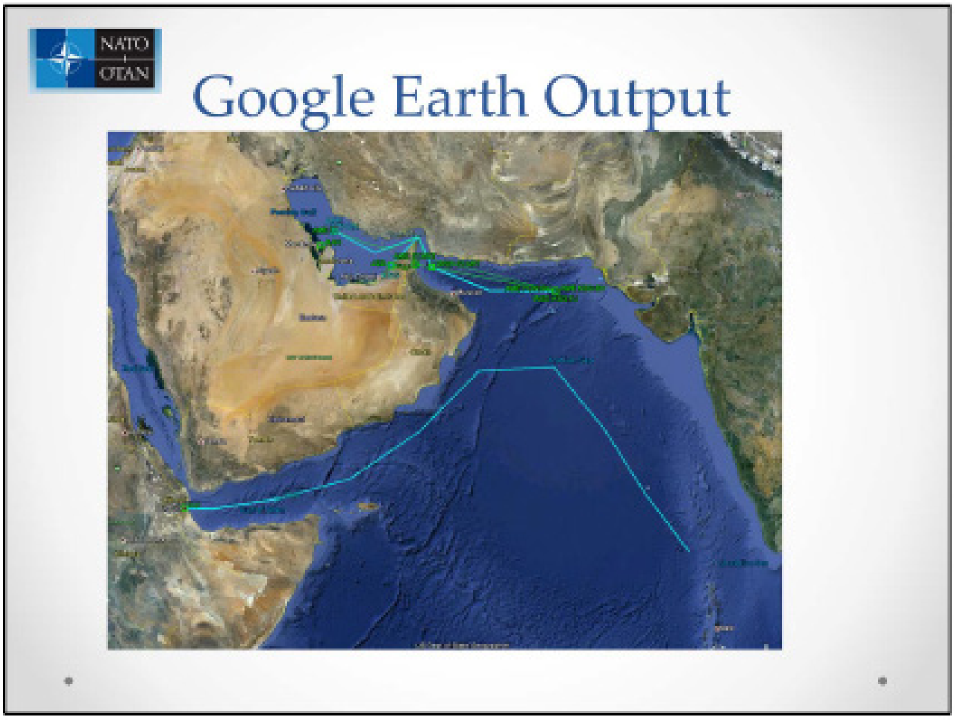
Partnership between MSC HQ and NPS

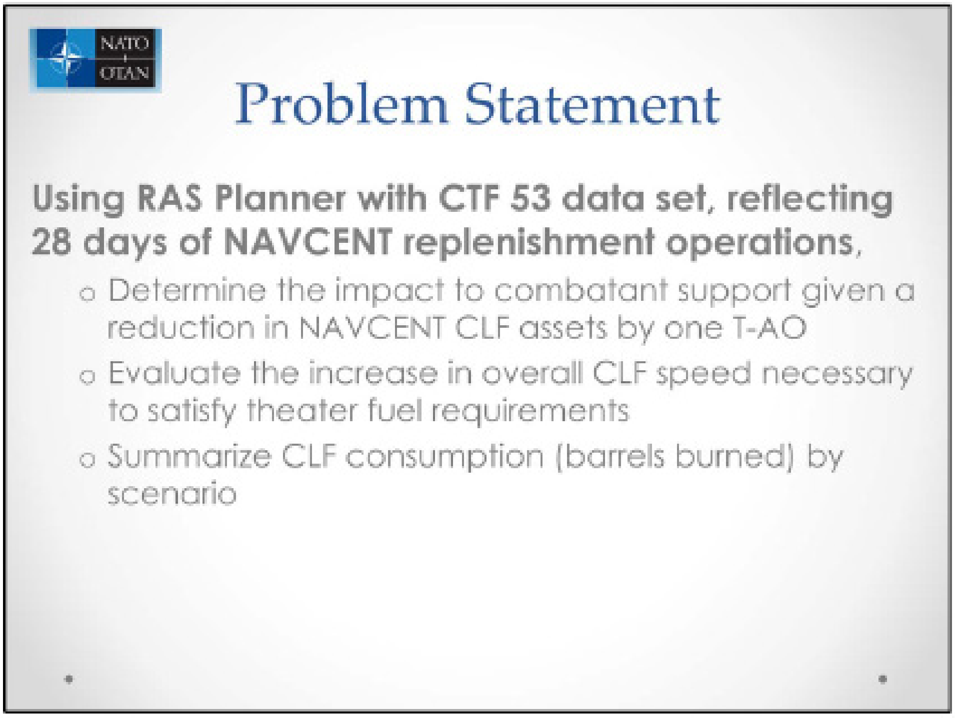
Present CLF employment options based on quantitative analysis

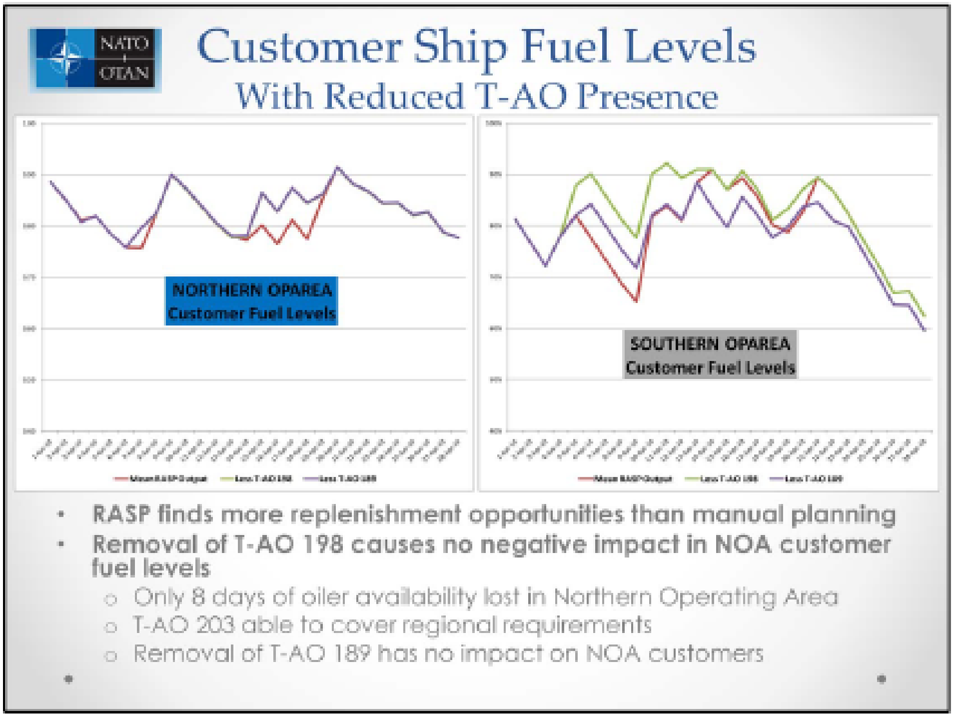
Reduce workload on CTF staffs

Enables tracking of fuel, provisions and ordnance based on combatant operations

CLF Costs: Fuel consumption, *port handling, commodity differentials*







Continued use of .40 – 1.00 range on Fuel levels axis to highlight differences (or lack thereof)

CLF Employment

(Fuel Deliveries in Barrels)

BBLs Delivered	TAKE 1	TAKE 2	TAO 189	TAO 198	TAO 203	TAO 204	North OPAREA Subtotal	South OPAREA Subtotal	Total (Barrels)
Four Oilers Data Set	16,265	33,203	23,243	50,105	77,344	61,226	160,652	100,734	261,387
TAO 198 Removed	14,736	54,677	13,744		104,506	73,323	159,182	101,802	260,984
TAO 189 Removed	14,825	54,993		38,570	66,022	85,467	159,585	100,292	259,876

- Color coding specific to operating area
- Both DFM and JP5 fuel products summarized
- Delivery quantities independent of scenario
  - ✓ Statistically insignificant differences in Total
  - ✓ Reflects stable customer requirements
  - ✓ No "bonus" points for unnecessary delivery

Customer demands can be satisfied with fewer assets

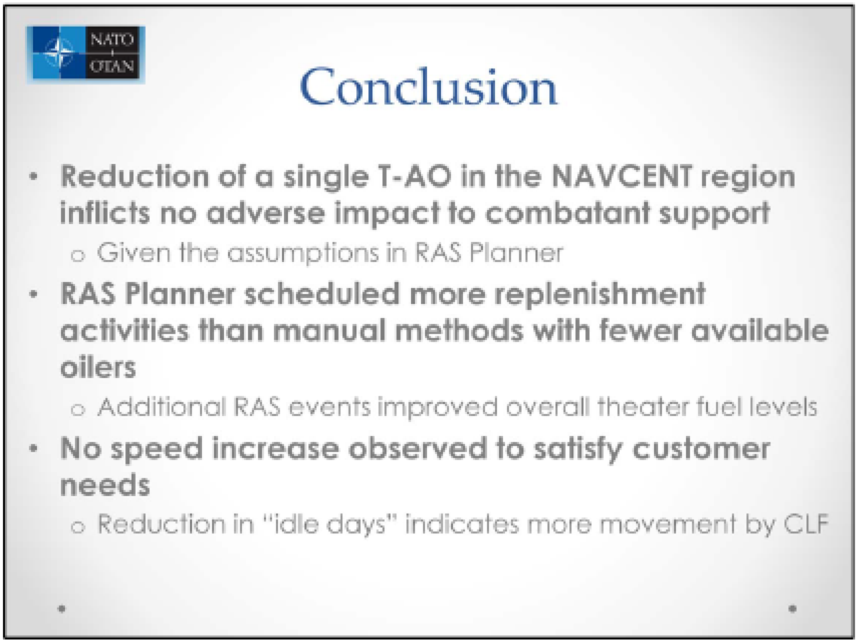
NOTE: deliveries for "Four Oilers Data Set" map to the events on OPREP-5 reports from the CTF 53 data set after reprogramming that schedule into RASP.

Customer demands can be met with three oilers and full use of TAKE capabilities … at SLOWER transit speed requirements

NEITHER coalition customers NOR coalition logistics support force units are reflected in the analysis.

CLF Bunker Fuel Consumed

	TAKE 1	TAKE 2	TAO 189	TAO 198	TAO 203	TAO 204	North OPAREA Subtotal	South OPAREA Subtotal	Total (Barrels Burned)
Four Oilers	2,608	4,642	2,044	1,049	5,562	3,277	11,253	7,929	19,182
TAO 198 Removed	3,012	5,205	2,116		3,391	3,367	8,596	8,494	17,090
TAO 189 Removed	3,012	5,205		1,076	2,244	3,222	8,525	8,234	16,758



Analytic questions:

Determine the impact to combatant support given a reduction in NAVCENT NFAF assets by one T-AO

Evaluate the increase in overall NFAF speed necessary to satisfy theater fuel requirements

Summarize CLF consumption (barrels burned) by scenario

Caveats:

Observed behavior in data set is not always explained by replenishment requirements

Reduction in CLF operational flexibility not captured

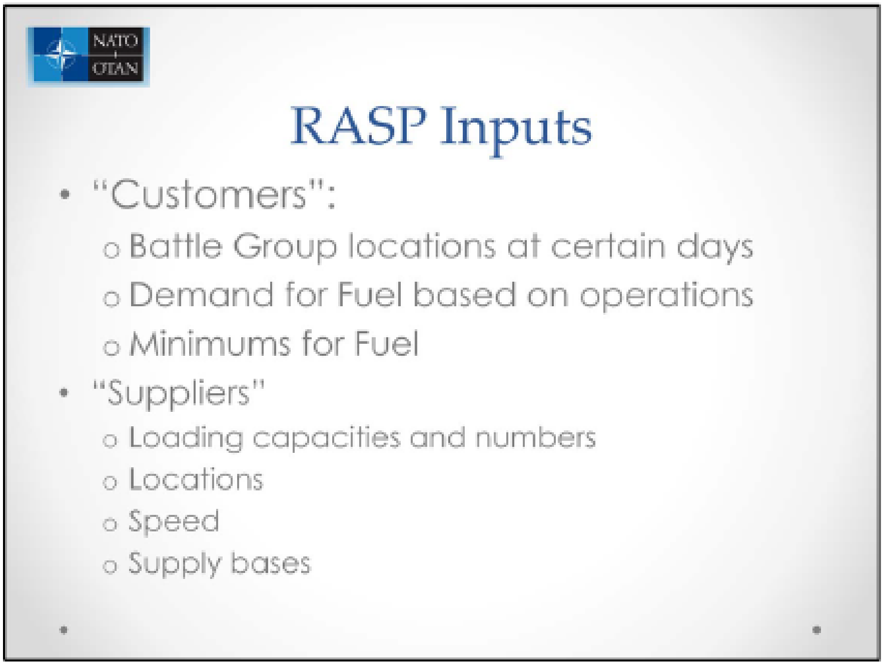
Neither Coalition forces NOR Coalition CLF assets reflected in analysis

What is Optimization?

- Field of applied mathematics that seeks to find the most cost effective or best performing alternative under given constraints by maximization of desired factors or minimizing undesired ones.
- In RASP's case, to minimize CLF costs while meeting battle ship demands.

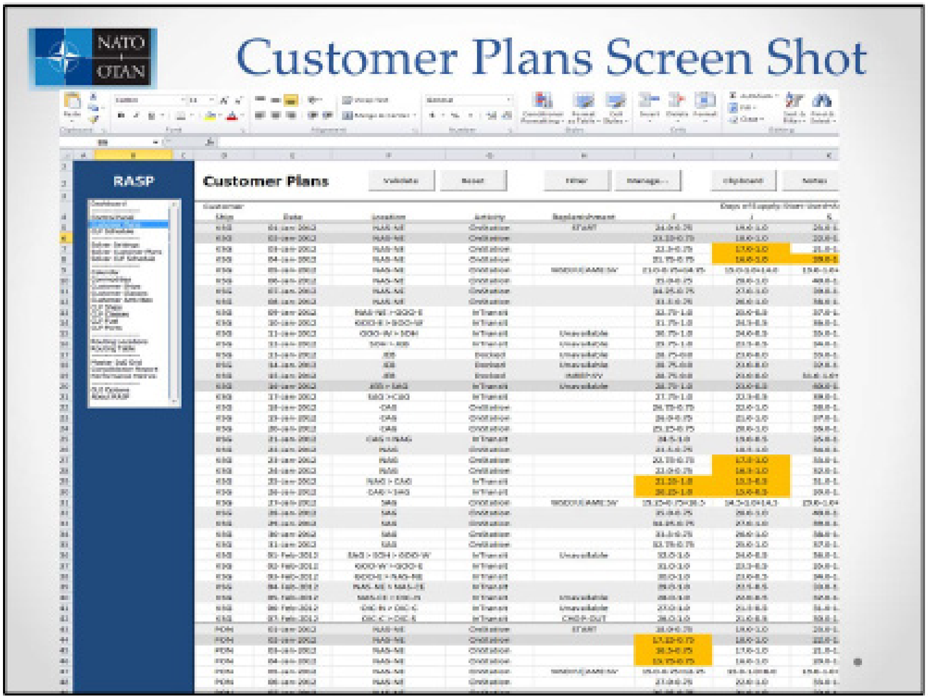
Strengths and Weaknesses of Optimization

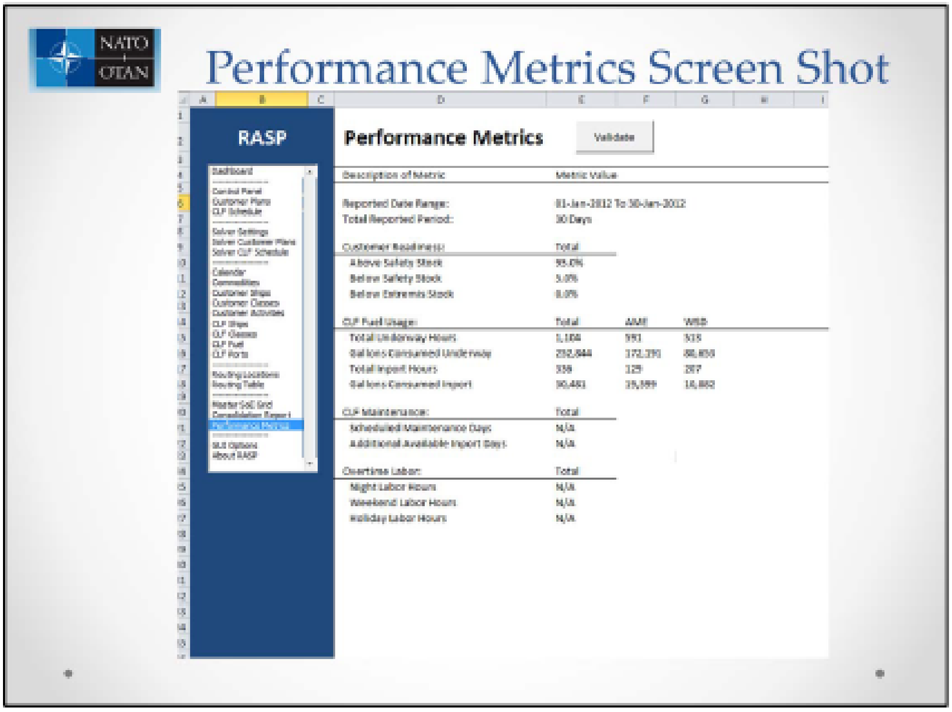
- Seen as an "If", "Then" statement: "If" this data, "then" this is the best course of action: need good data.
- Optimizing versus Satisficing: Ideal schedule versus reality
- Great asset for quick "What-If" analysis



A couple screen shots

A couple screen shots


NATO
OTAN
Customer Plans Screen Shot
RASP
Customer Plans

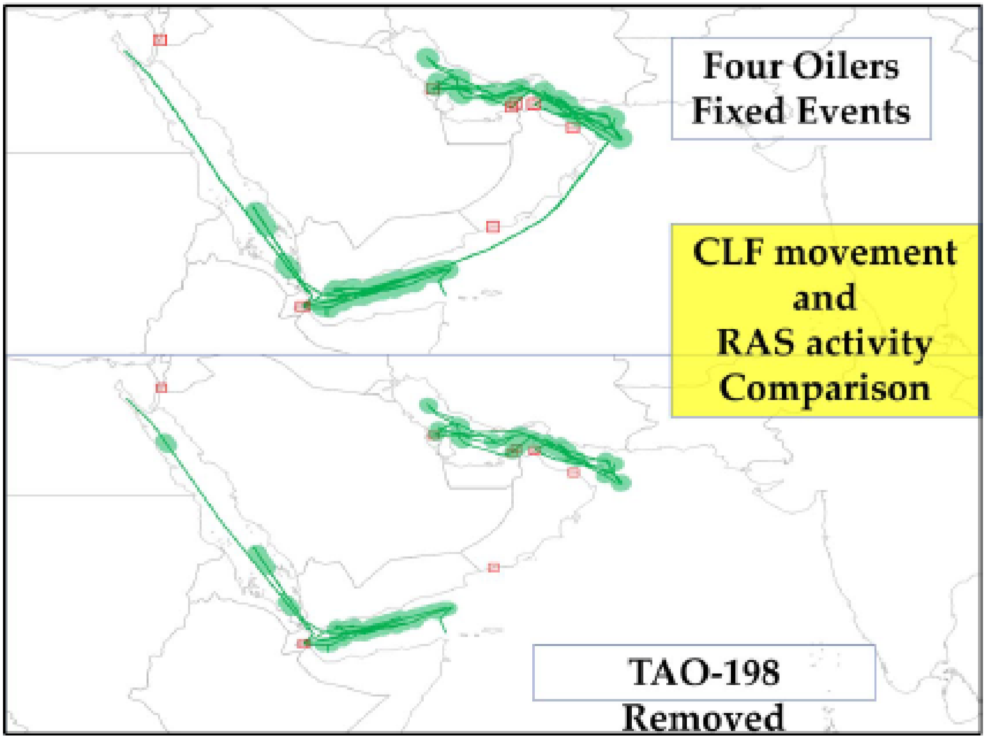

NATO
OTAN
Performance Metrics Screen Shot
RASP
Performance Metrics
Validate
Description of Metric
Metric Value
Reported Date Range:
01-Jan-2012 To 30-Jan-2012
Total Reported Period:
30 Days
Customer Readiness:
Total
Above Safety Stock
95.0%
Below Safety Stock
5.0%
Below Extremis Stock
0.0%
CLF Fuel Usage:
Total
AME
WSB
CLF Maintenance:
Scheduled Maintenance Days
N/A
Additional Available Inport Days
N/A
Overtime Labor:
Night Labor Hours
N/A
Weekend Labor Hours
N/A
Holiday Labor Hours
N/A

RASP Take-Aways

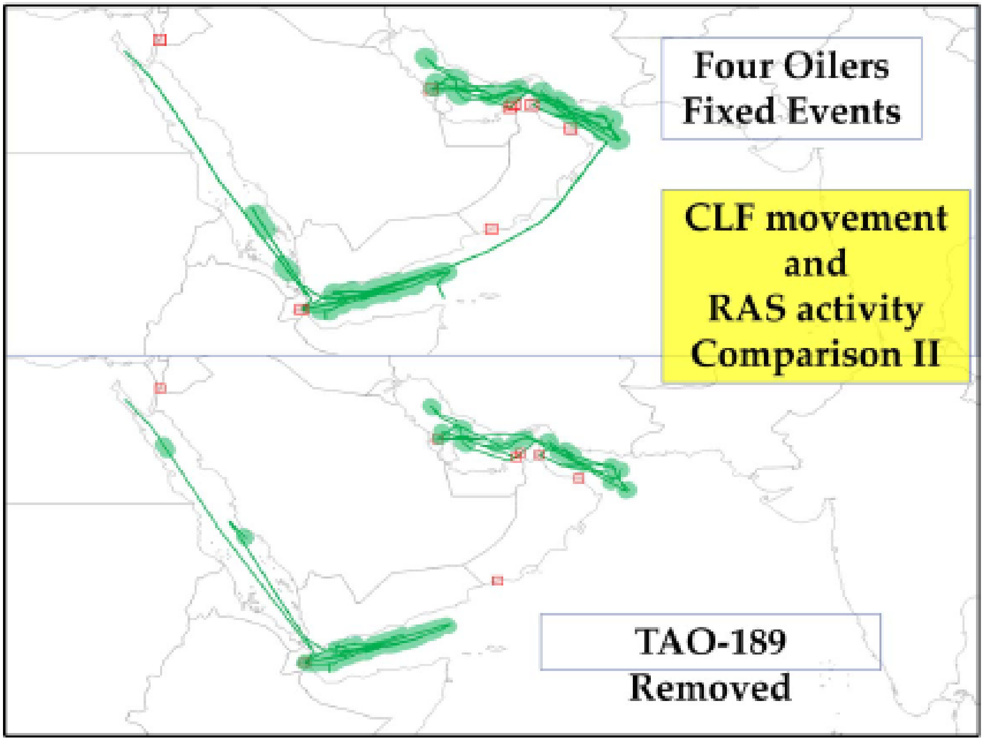
- Operational planning tool
  - Optimized replenishment schedule
  - Not applicable to every organization / CONOPS
  - Extremely adaptive to planner requirements
- Analysis tool
  - Provides simulation capability
    - Enables quantitatively-based excursion assessments
- Administrative tool
  - Screen shots provide briefing assistance
  - Data capture allows improve database management
  - Report generation capability to reduce staff workload

Methodology for the Analysis

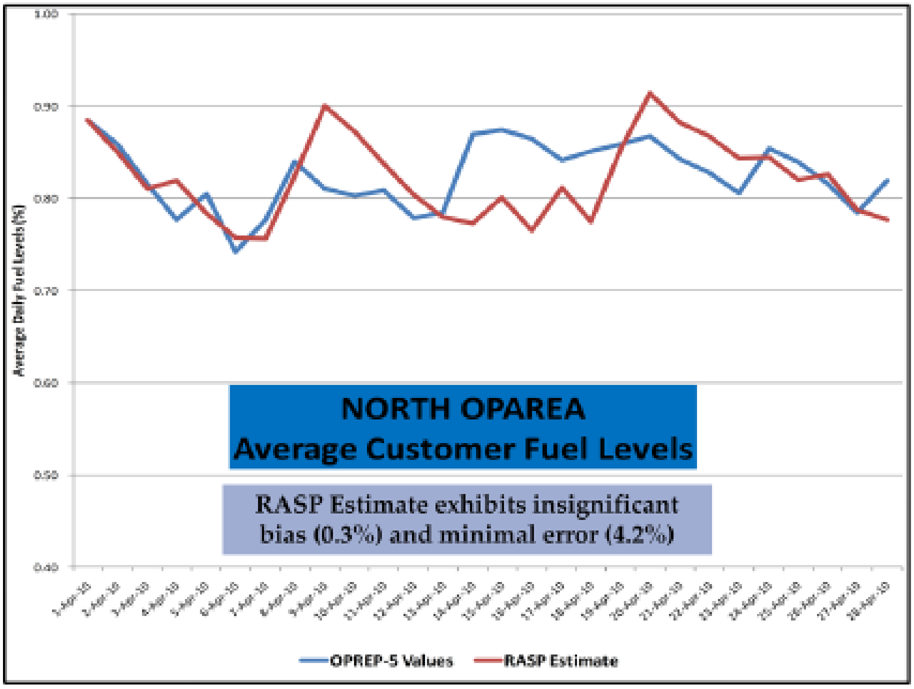
- Establish applicability of RAS Planner (RASP)
  - Compare OPAREA customer mean fuel levels
- Run RASP after removing T-AO 198
  - Reduces 8 days shuttle oiler coverage
- Run RASP after removing T-AO 189
  - Restore T-AO 198
  - Reduces 28 days shuttle oiler coverage
- Evaluate regional CLF availability



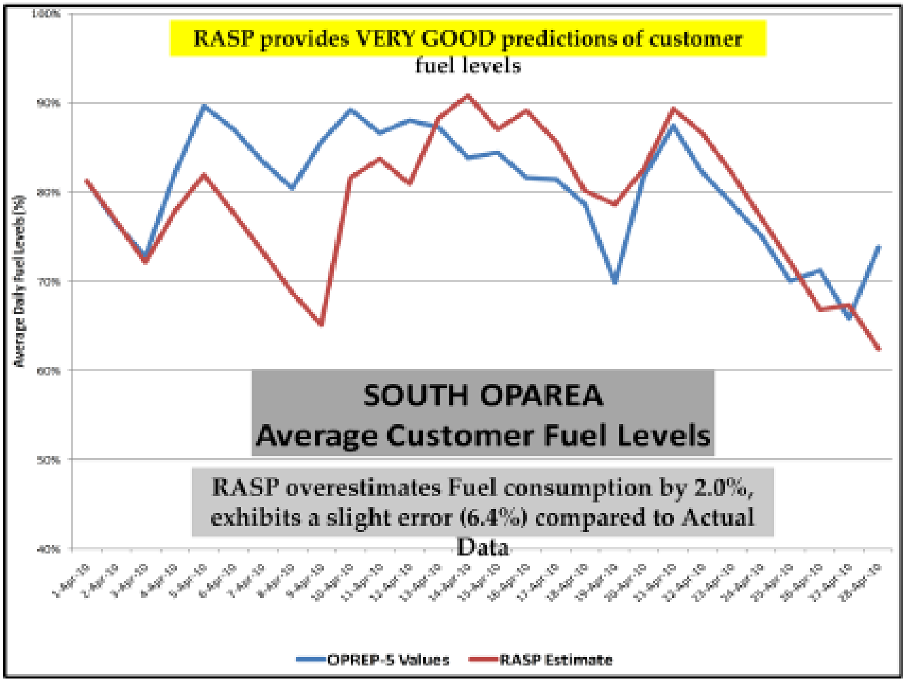
Reminder: TAO-198 active for only 9 days during time horizon



Reminder: TAO-189 active for full 28 days



NORTH OPAREA baseline: model tends to underforecast customer fuel levels, meaning that fuel state in reality is BETTER than RASP indicates.
TAKE AWAY: RASP effectively models customer fuel consumption



SOUTH OPAREA baseline: similar outcome as NORTH. While NOT AS ACCURATE AS NORTH (smaller units cause greater variability – "skipped" fueling event), still a VERY GOOD approximation to reality. Under-estimation is better than overestimation.

CLF Employment

(Fuel Deliveries in Barrels)

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T-AO Employment

(Operating Hours)

	Operating Conditions (by Speed)	TAO 189 (Hours)	TAO 198 (Hours)	TAO 203 (Hours)	TAO 204 (Hours)	Scenario Subtotals (Hours)	Average Speed (kts)	DFM Burned (Bbls / % Chg)
Four Oilers Data Set	Idle	450	164	248	413	1276	5.2	11932
	Overspeed	4	0	92	12	108	34.7	--
TAO 198 Removed	Idle	255		164	267	686	4.6	8874
	Overspeed	4		12	44	60	33.5	-26%
TAO 189 Removed	Idle		91	198	224	513	5.2	8542
	Overspeed		0	4	36	40	39.3	-28%

Employment results of the three scenarios displayed in table format, featuring the number of hours for each unit either spent idle of requiring transits in excess of 20 knots (a feature that allows RASP to reach a solution with crashing due to Planner manual inputs.)

It is worth highlighting that 28 days of activity amount to a maximum hours of scenario time of 672. So, that T-AO 189 spent 450 hours of that period idle indicates a significant amount of slack – or unaccounted for time with NO speed requirements – in the schedule. A follow on slide reflects these values in terms of percentage.

The average speed column shows both the overall weighted mean speed (including overspeed) required to execute the RASP solution AND the weighted mean of the Overspeed time. These values allow for a comparison with the relative efficiency of the schedules. The TAO 189 scenario has almost 1/3 the Overspeed hours but requiring a slightly faster speed to realize the solution. NOTE: overspeed conditions are only created due to Planner-inserted replenishment events.

Operating Status Explained

- "Idle" status reflects periods of relative inactivity:
  - At sea, loitering for customers
  - In port, typically cargo loading
  - Exhibits "slack" in the RAS schedule
- "Overspeed" indicates a speed requirement in excess of ship capability to arrive at a solution
  - RASP tolerates manually entered events causing overspeed conditions (otherwise infeasible)
  - Overspeed time is highlighted on fuel curve graphic
  - Loosened constraint enables planner to identify and revisit potentially problematic RAS assignments

Operating at Extremes

(Percent of Time Idle or Overspeed)

	Operating Conditions (by Speed)	TAO 189 (% Time)	TAO 198 (% Time)	TAO 203 (% Time)	TAO 204 (% Time)	Scenario Subtotals (% Time)
Four Oilers (Data Set)	Idle	71%	70%	46%	60%	61%
	Overspeed	2%	0%	17%	2%	5%
TAO 198 Removed	Idle	47%		30%	39%	37%
	Overspeed	1%		2%	6%	3%
TAO 189 Removed	Idle		39%	37%	33%	35%
	Overspeed		0%	1%	5%	3%

- "Idle" status reflects periods of relative inactivity:
  - At sea, loitering for customers
  - In port, typically cargo loading
  - Exhibits "slack" in the RAS schedule
- "Overspeed" indicates a speed requirement in excess of ship capability to arrive at a solution
  - RASP tolerates manually entered events causing overspeed conditions (otherwise infeasible)
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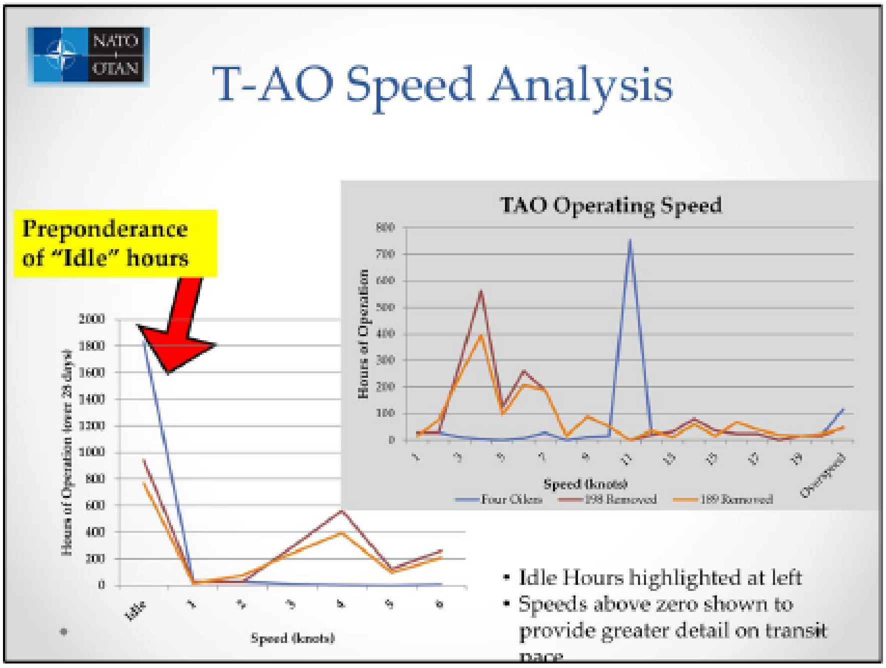
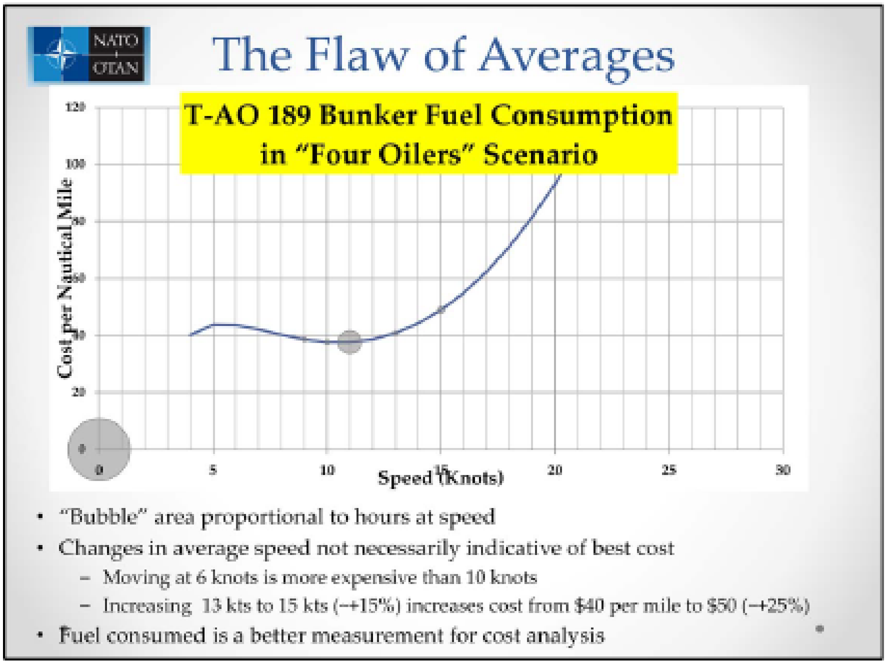


The overlaid graph is to show more detail to the overall speed requirements of each scenario without being overwhelmed by the IDLE hours data, which is captured in the side graph.

The fuel curves indicate a very shallow efficiency valley for the KAISER-class fleet oiler from about 7 knots to 13 knots, reflected above in RASP utilization of those lower speeds to achieve it's schedule requirements.



T-AKE Performance

T-AKE 1	RAS (DFM)	RAS (JP5)	Load (DFM)	Load (JP5)	UNREPS	INREPS
Four Oilers	(13,702)	(2,562)	-	-	3	1
TAO 198 Removed	(11,921)	(2,814)	-	-	4	1
TAO 189 Removed	(12,007)	(2,817)	-	-	4	1

Scenario

Recall:

- T-AKE 1 operated in the SOA, supporting mostly small combatants
- T-AKE 2 operated in the NOA in direct support of the CVN as well as the LHD in transit

T-AKE 2 breaks out “Stores Only” UNREPS to showcase the underutilization of the refueling capability in the fixed event scenario; however, two additional JP5 hits given to CVN without stores in the other scenarios may not be acceptable practice.

T-AKE Performance

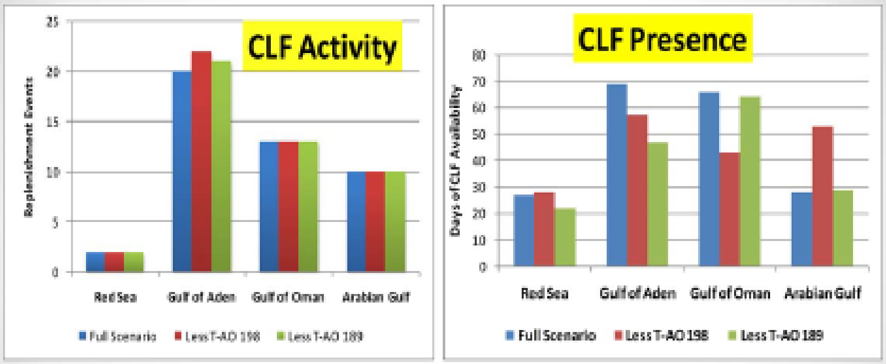
T-AKE 2	Scenario	RAS (DFM)	RAS (JP5)	Load (DFM)	Load (JP5)	UNREPS	UNREPS (stores)	INREPS
Four Oilers		(27,968)	(5,236)	15,112	786	12	7	4
TAO 198 Removed		(39,836)	(14,840)	26,875	10,390	11	2	4
TAO 189 Removed		(40,153)	(14,840)	27,192	10,390	11	1	4

Recall:

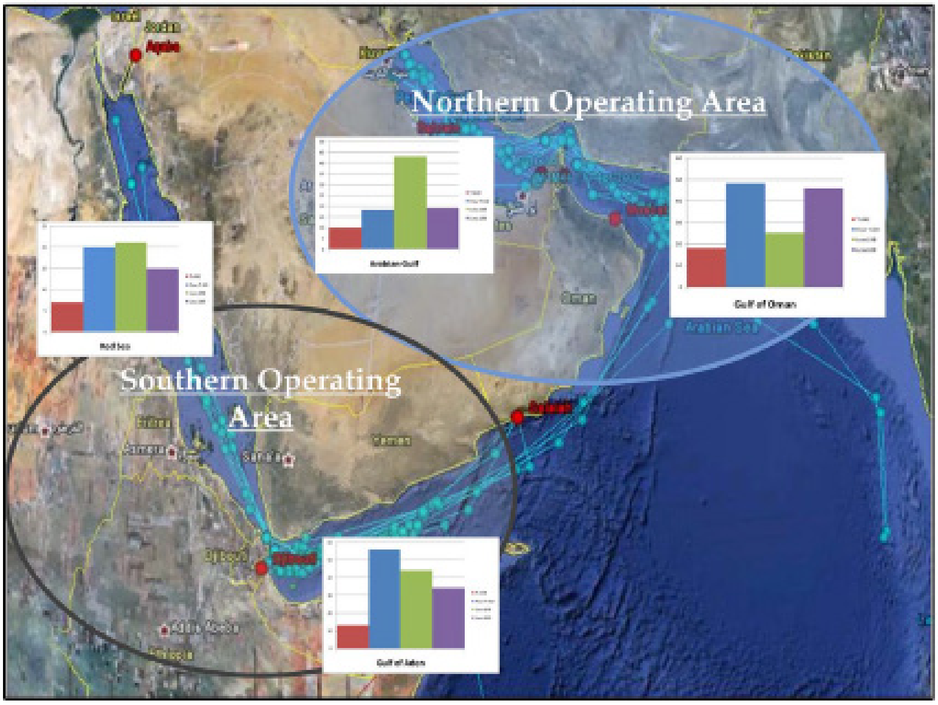
- T-AKE 1 operated in the SOA, supporting mostly small combatants
- T-AKE 2 operated in the NOA in direct support of the CVN as well as the LHD in transit

T-AKE 2 breaks out "Stores Only" UNREPS to showcase the underutilization of the refueling capability in the fixed event scenario; however, two additional JP5 hits given to CVN without stores in the other scenarios may not be acceptable practice.

Hull Presence (CLF)



- RASP schedules additional events to satisfy of customer requirements
  - Despite fewer days of CLF availability, more RAS events were conducted
- In Data Set, T-AO 203 surges from Gulf of Oman to Gulf of Aden fm 9 – 13 April
  - RASP did not replicate this behavior, increasing CLF presence in Arabian Gulf

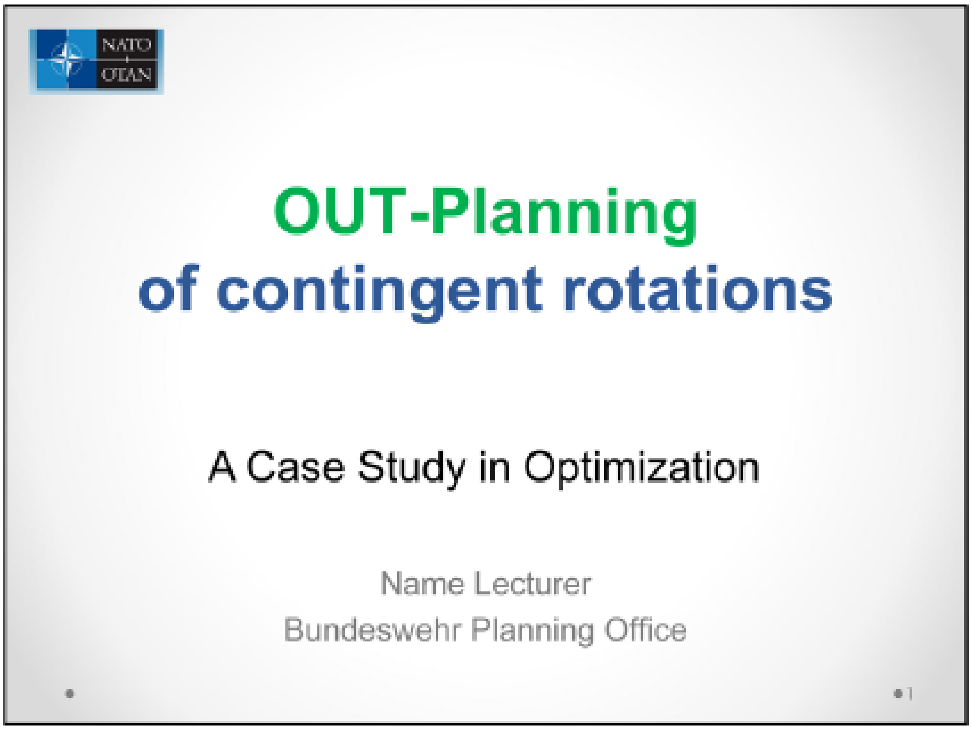


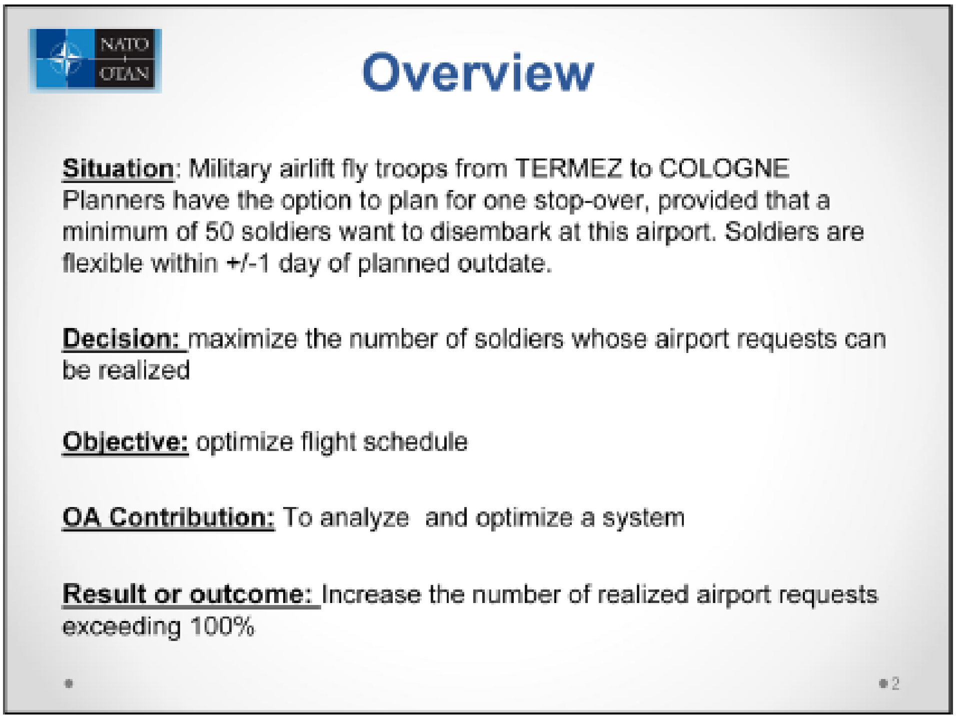
Spike in Arabian Gulf support due to T-AO 203 stationing in NOA for duration of period, vice four day sortie to SOA in Fixed scenario.

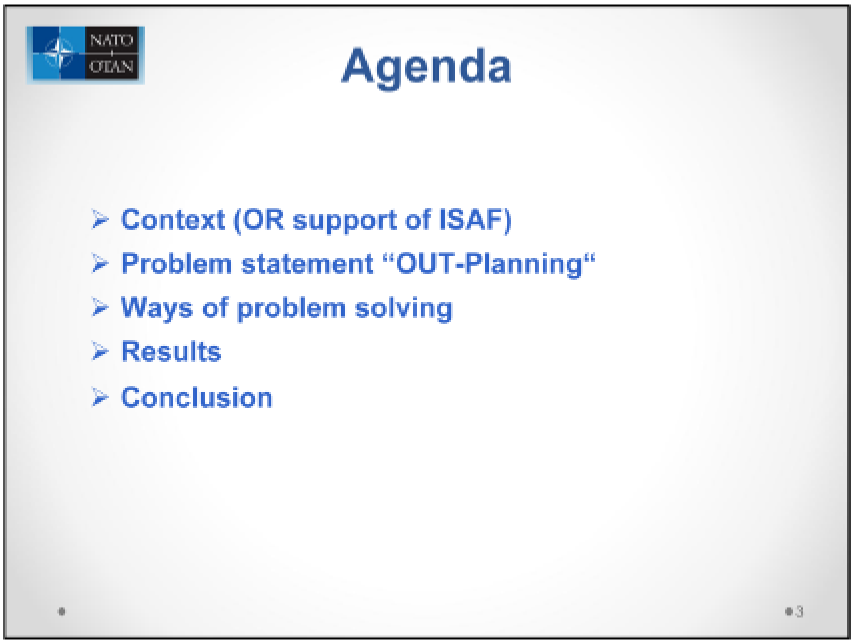
A.5.3 Out-Planning

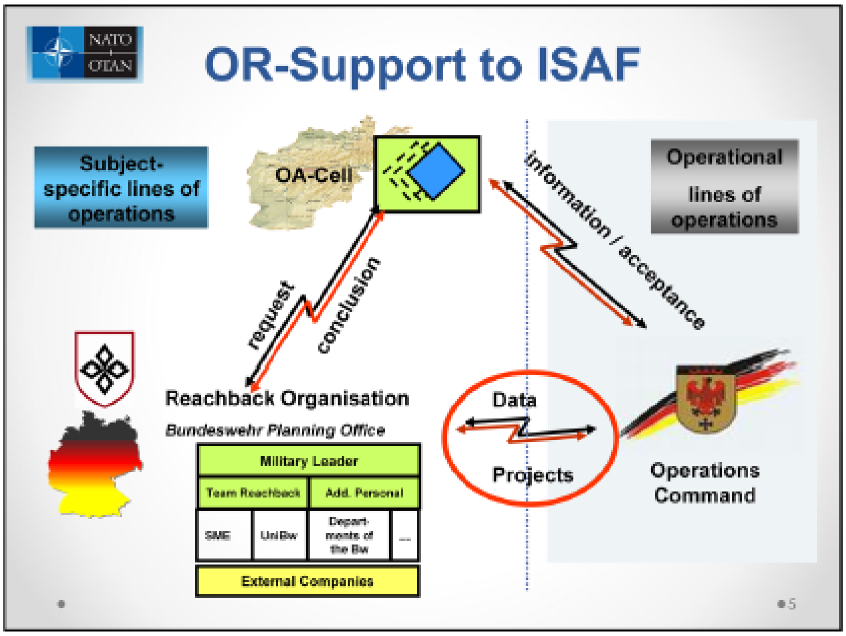
INSTRUCTIONAL MODULE SUMMARY

Title	Optimization of OUT-Planning in the Context of Contingent Rotations
Faculty Name(s)	Bundeswehr Planning Office, Ottobrunn, DEU
Length	20 – 30 minutes
Learning Objectives	Understand that OR-methods can improve complex planning.
Outcomes	As the result of this module, participants will be able to: Recognize similar applications where an analysis by OA staff could support planning.
Content Outline	Case Study: Optimization of OUT-planning.
Materials	None.
Methods	100% Lecture 0% Class Exercises. ____ % Break Outs.
Exercise(s)	None.
Break Outs	___ Yes X No. __#___ participants in each break out group.
Discussion Questions	Did you have a similar case in the past? Can you think of a current case in your area of responsibility?


NATO
OTAN
OUT-Planning
of contingent rotations
A Case Study in Optimization
Name Lecturer
Bundeswehr Planning Office
1


NATO
OTAN
Overview
Situation: Military airlift fly troops from TERMEZ to COLOGNE
Planners have the option to plan for one stop-over, provided that a minimum of 50 soldiers want to disembark at this airport. Soldiers are flexible within +/-1 day of planned outdate.
Decision: maximize the number of soldiers whose airport requests can be realized
Objective: optimize flight schedule
OA Contribution: To analyze and optimize a system
Result or outcome: Increase the number of realized airport requests exceeding 100%
2





The Bundeswehr OR support to ISAF operations has been provided since 2007.

As you can see on the slide, OR support to operations is characterized by close collaboration and co-ordination between the German Joint Forces Command, the OR cell in Afghanistan, and the Reachback organization in Germany.

The OR cell is the focal point in theater. It gathers inputs for future analysis and also conducts "first-line" analysis. If needed, the Reachback organization supports further analysis by providing research support or serving as a coordination element with other national military or scientific organizations in Germany. The Joint Forces Command serves as the operational headquarters for all Bundeswehr operations abroad.

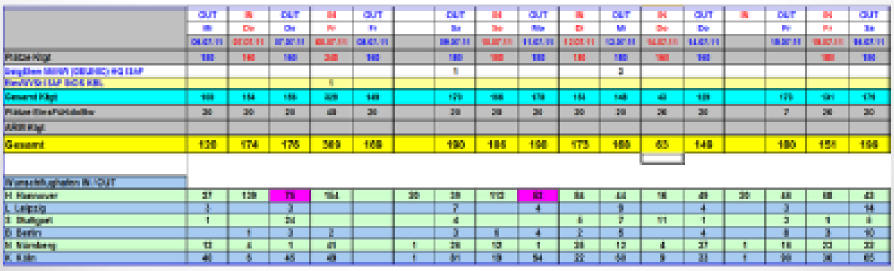
Problem Statement OUT-Planning

- During contingent rotation several thousand soldiers are to be flown out via Mazar-e Sharif to Germany
- The airplane flies to Cologne on a regular basis; on demand (min. requirement: 50 people) a stop-over can be planned (e.g. in Berlin, Hannover, Stuttgart, Nuernberg)
- Every soldier can select the airport that is closest to his home (-base)
- Assumption: the out-date can be changed by +/- one day
- Aim: maximize the number of desired airport requests

7

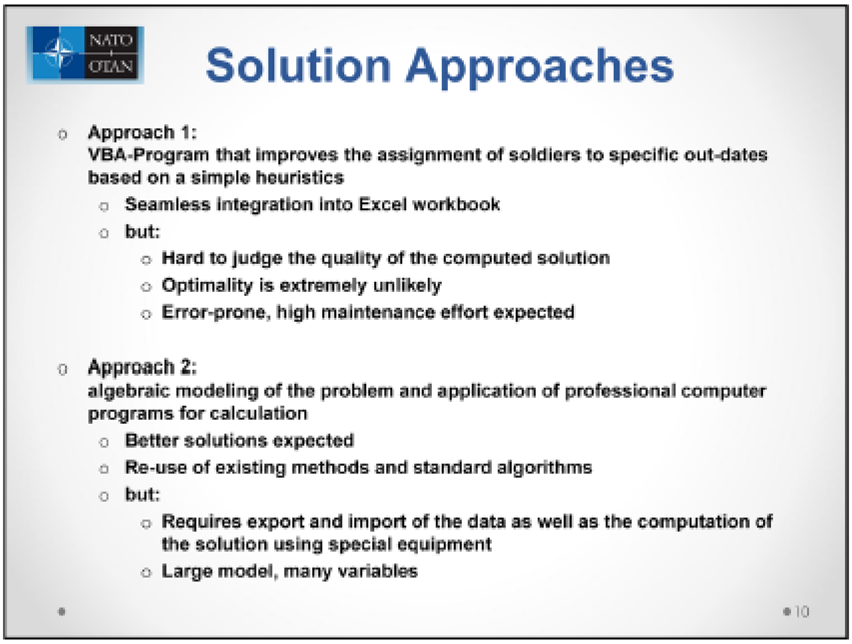
Results of manual planning

- The Excel template for the flight planner is very complex and rarely suited for manual optimization
- The figure shows the cumulated data of a past OUT-planning result
- On several consecutive days the chance for Hannover was closely missed



8

The flight planner uses an Excel-Sheet for manual planning. The problem is too complex to quickly find an optimal solution just by working with passenger lists on a manual basis. The depicted figure shows a planning overview where the bound of 50 people for a stop in Hannover was closely missed.



Two approaches where realized, but only the second one really found the optimal solution. The first is a greedy heuristic realized via Virtual Basic for Applications (VBA) in Excel. This was easy to integrate to the Excel-Sheet of the flight planner but cause of the heuristic approach it is difficult to judge the quality of the solution. The error-prone is very high.

The second approach is to model the problem algebraic. The advantage is that you can use existing and standard algorithm to solve the problem. The quality of the solution should be better, but you have to export and import data from the Excel-Sheet to compute the solution with a separate tool. Due to the complexity of the problem it is not linear and the model grows very fast because you have many variables and restrictions. The computation time could enlarge.

Model (1)

- Set of soldiers
- Set of OUT-days
- Set of stop-over airports

sets

- Capacity of airplane
- Airports requested by soldier
- Possible OUT-days of soldier

constants

- Flight plan
- OUT plan

variables

- Number of soldiers satisfied

target function happiness

11

Modell (2)

- Every soldier is flown out exactly once.
- The assigned date has to be possible.

Side conditions

- The capacity of the aircraft must be taken into account.
- Maximum of one stop per flight.
- If there is a stop, at least *50* soldiers have to debark.

12

Implementation Details

- Assumptions of the model have been validated by OR analysts and flight planners in-theater
- Using a common Algebraic modeling tool for the computation of solutions
- First experiments by Reachback team with two open source solvers, but these did not manage to come up with probably optimal solutions in a reasonable time due to the large size of the input models
- Still for the example data of past OUT plannings the computed solutions were +60 better than the heuristic approach and magnitudes better than the result of the planning by hand!

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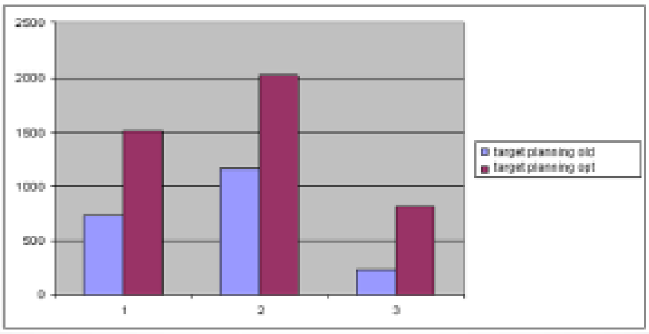
Quality of Solutions

Dataset	1	2	3
Number of Soldiers	ca. 3000	ca. 4000	ca. 2000
Target function value for old planning result	730	1165	230
Target function value computed by solvers	1513	2028	814
Improvement	**+107%**	**+74%**	**+254%**



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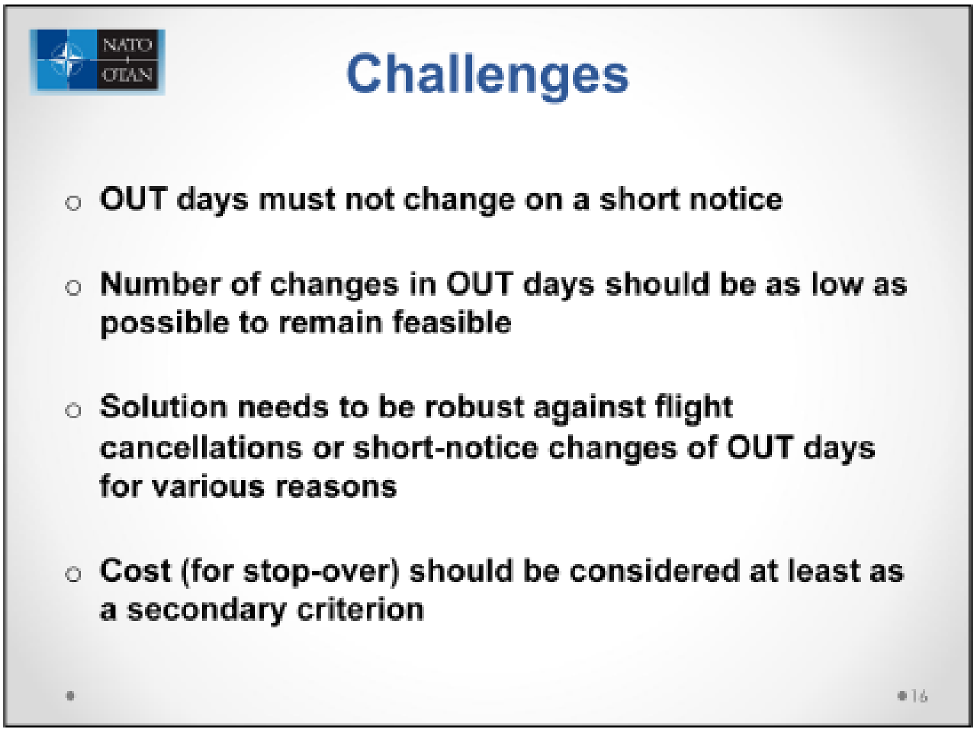
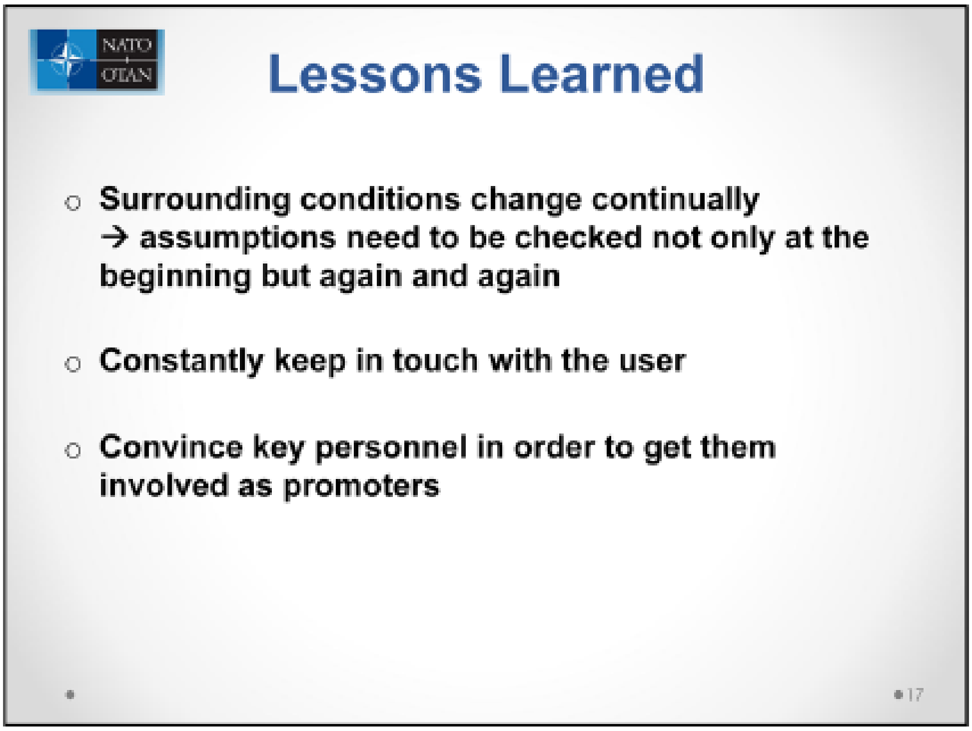
Here you can see a comparison of the planning by hand and the planning with approach 2. As you can see an improvement is possible. The number of soldiers which airport request could be realized doubled.


NATO OTAN
Challenges
OUT days must not change on a short notice
Number of changes in OUT days should be as low as possible to remain feasible
Solution needs to be robust against flight cancellations or short-notice changes of OUT days for various reasons
Cost (for stop-over) should be considered at least as a secondary criterion
16


NATO OTAN
Lessons Learned
Surrounding conditions change continually → assumptions need to be checked not only at the beginning but again and again
Constantly keep in touch with the user
Convince key personnel in order to get them involved as promoters
17

Conclusion

- Project has the potential to improve the satisfaction of our troops and to promote the application of OR methods
- Flight planning is a classical optimization problem, this problem touches on is a new aspect
- Different approaches and models had to be explored in order to achieve a tangible result
- Professional tools are required for productive OR work

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Impressum

- Created by: Bundeswehr Planning Office
- References: TBD
- Materials: TBD
- Lecturer: LTC Burgert

20

A.5.4 Stockpile Planning Guidance

INSTRUCTIONAL MODULE SUMMARY

Title	Methodology to Derive Stockpile Guidance for NATO MC 55/4
Faculty Name(s)	Han de Nijs, NATO HQ SACT, Norfolk VA, USA
Length	45 – 60 minutes Lecture; Additional 30 minutes Exercises and Discussion
Learning Objectives	Appreciate the value of simple models, assumptions and conclusions that can be immediately grasped by decision-makers. Appreciate the need for quick analysis that is relevant for a problem that is imminent at NATO Committee levels.
Outcomes	As the result of this module, participants will be able to: Understand the impact analysis can have on investment in stocks and material by the NATO Nations. Understand the power of analytical models that are simple but relevant. Understand the need for analysts to be familiar with subject matter.
Content Outline	A Case Study of application of simple model for the determination of NATO stock levels to be maintained by forces to be deployed in NATO operations.
Materials	List Required Pre-Readings: NATO Logistics Handbook, November 2012: http://www.nato.int/docu/logi-en/logistics_hndbk_2012-en.pdf
Methods	60% Lecture; 30% Breakouts for Exercises; 10% Class Exercises; Discussions
Exercise(s)	Estimate cost savings in stock levels for Class I and/or Class II for the new policy for armed forces of your Nation. Estimate lead times for the production (either in home country or in host Nation) of some classes of stocks (Class I, II, III and/or IV). Determine situations where you think the re-supply time T_2 would make a difference and cannot be neglected. Are all assumptions always right?
Break Outs	X Yes ___ No. __#_5__ participants in each break out group.

Discussion Questions	Discuss questions arising from exercises? Other questions: Is this model too simple? What can be improved? Although Nations welcomed the outcomes on one hand, they were not happy with on the results on the other hand when they applied it to munitions. What is the reason for that? If this would have been a result of simulations would it have had the same or a different impact on decision-making?

Overview

1. **Situation:** Stockpile Requirements for NATO nations expressed as a simple 30 Days of Supply (DOS) for all classes of supply is not anymore economic feasible
2. **Decision:** Agree in NATO forum on new levels
3. **Objective:** Reasonable and Justifiable Stock Levels
4. **OA Contribution:** Provide rationale for stock levels required for each class of supply that includes transparent logic, easy compliance measures and reasonable burden

2

Background (1)

- MC-317 - NATO Force Structure Review[1] resulted in the adoption of principle of Graduated Readiness to provide
  - o flexibility for conducting full range of missions and
  - o sustainability to ensure collective defence
- NATO Force Structure distinguished
  - o Higher Readiness Forces (HRF)
  - o Forces of Lower Readiness (FLR)
  - o Long Term Build-up Forces (LTBF)
- Revision of Logistic Readiness and Sustainability MC-55/3 was necessary

1) MC 317 of 16 Dec 1991 was superseded by MC 317/1 of 8 July 2002

3

Background (2)

- MC 55/3: Requirement that nations have stockpiles for all classes of supply for 30 days for all their forces declared to NATO.
- MC 55/4 Starting point: To optimize flexibility of nations in how they meet logistics readiness and sustainability requirements by the end of the specified readiness preparation time
- Change in perception: from sustainment to sustainability, i.e. the ability to sustain ready forces in time

4

NATO Classes of Supply

- Class I – Items of Subsistence, e.g. food and forage
- Class II – Supplies for which allowances are established by Tables of Organization and Equipment (TOE), e.g. clothing, weapons, tools, spare parts, vehicles
- Class III – Petroleum, Oil and Lubricants (POL) for all purposes (except for operating aircraft or for use in weapons)
  - Class IIIa – Aviation Fuel and Lubricants
- Class IV – Supplies for which initial issue allowance are not prescribed by approved issue tables

  (e.g. fortification and construction, as well as additional quantities for items authorized for initial use)
- Class V – Ammunition, explosives and chemical agents

5

Considerations that..

- Logistics plans must ensure that sufficient quantity and quality of logistics resources are available at the same readiness and deployability levels to support forces until such time as a stable, robust re-supply system has been established
- Stockpiling has to take into account the demand for supplies that arise from NATO's ambition for operations and the requirements for collective defence
- Reflect the trend towards integrated military logistics chain management and the increasing importance of partnering with industry
  - Industrial and commercial market considerations
  - Strategic transportation availability
  - Access to strategic materials

6

.. lead to the bottom line

- Need to have sufficient stocks for High Readiness Force (HRF) units that are ready to deploy based on the perceived need for supplies in the operation until a stable and robust re-supply system is in-place

Balanced against

- Requirement for stockpiling to be flexible where Forces of Lower Readiness (FLR) and Long Term Buildup Forces (LTBF) are needed – specifically when deploying in roulement of the HRF of same nation

7

Determine Stock Levels

- How to determine agreed level of stocks?
  - NATO uses an agreed model to compute Munitions Stockpiles
  - There are no agreed models for other classes of supply
  - Supplies to be based on typical demand that arises from the NATO assumptions for typical operations in which NATO is willing to engage
- Agreement on what is consumed: Standard Day of Supply (SDOS)
  - The total amount of supplies required for an average day based on Standing Group NATO rates and/or national rates as appropriate
- How to agree on what is required for the unit ready to deploy?

8

OA Contribution

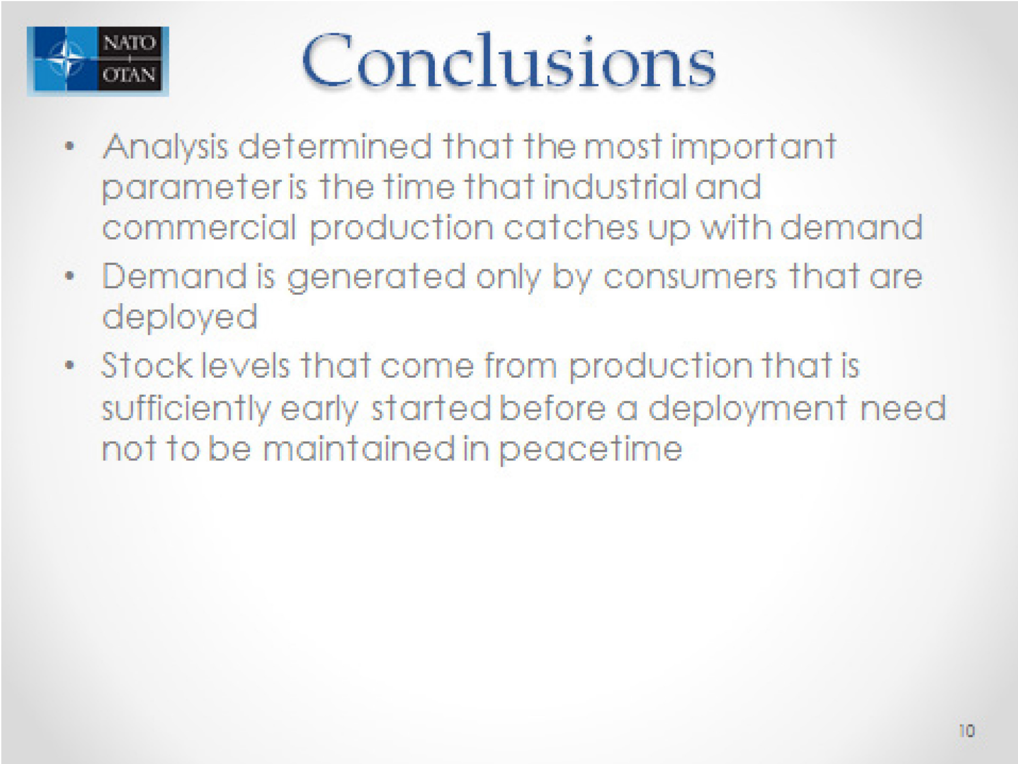
Devise method with simple rules

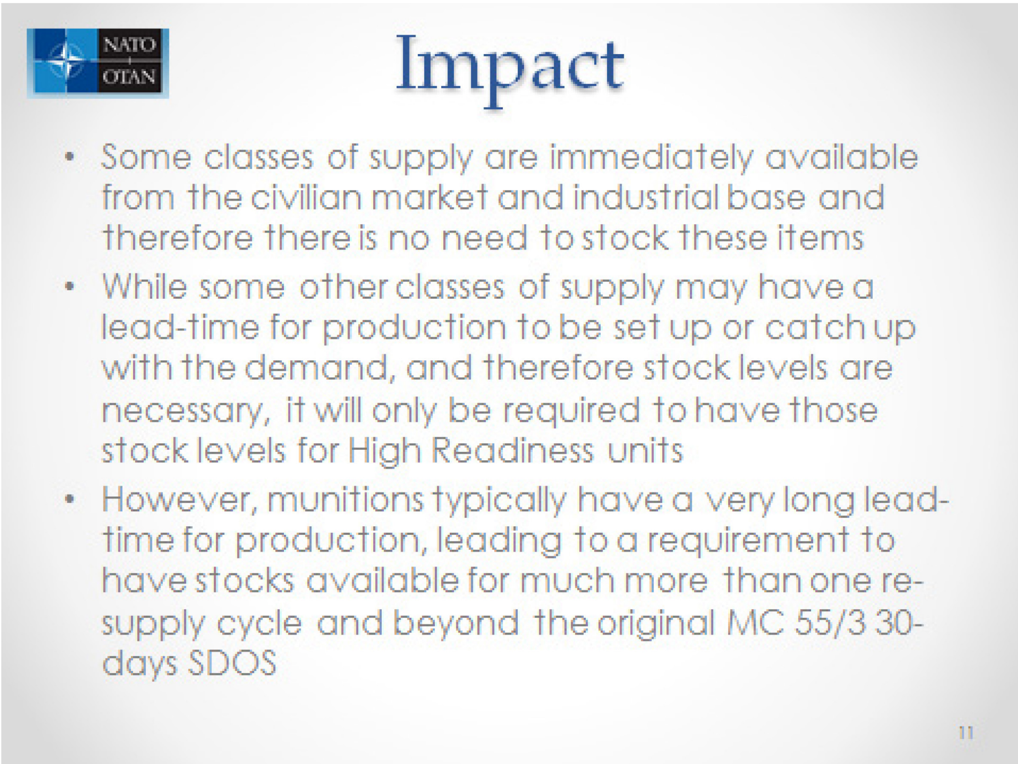
- Based on steady state in unit deployment
- Which will produce a demand that must be equaled by production:
  - P=C*X
  - P=Daily Production / Output Level of Home Base Industry
  - C=Daily Consumption rate
  - X=Number of Consumers

Consider Battle Damage Munitions separately

Call it the **Equilibrium Methodology**

9


NATO
OTAN
Conclusions
• Analysis determined that the most important parameter is the time that industrial and commercial production catches up with demand
• Demand is generated only by consumers that are deployed
• Stock levels that come from production that is sufficiently early started before a deployment need not to be maintained in peacetime
10


NATO
OTAN
Impact
• Some classes of supply are immediately available from the civilian market and industrial base and therefore there is no need to stock these items
• While some other classes of supply may have a lead-time for production to be set up or catch up with the demand, and therefore stock levels are necessary, it will only be required to have those stock levels for High Readiness units
• However, munitions typically have a very long lead-time for production, leading to a requirement to have stocks available for much more than one re-supply cycle and beyond the original MC 55/3 30-days SDOS
11

What was the Decision?

- Only for units in High Readiness
- 30 SDOS is the general guidance
- More specifically:
  - Class I: No military requirement to stockpile fresh rations; for potable water it is left to nations to assure availability of 30 SDOS
  - Class II: An 30 SDOS is not generally applicable, except for a few items (NBC Clothing)
  - Class III: 30 SDOS ready availability of bulk products
  - Class IV: Mainly time-independent and mission driven; 30 SDOS not applicable
  - Class V: Battle Damage Munitions follow level of effort methodology and non-BDM requirement is 30 SDOS

12

Final Result

- The new MC 55/4 led to a drastic reduction in volume and cost to nations of material to be routinely stockpiled to meet NATO readiness and sustainability needs

13

NATO OTAN

More Details Follow

• • •

14

NATO OTAN

OA Contribution

Devise method with simple rules

- Based on steady state in unit deployment
- Which will produce a demand that must be equaled by production:
  - o P=C*X
  - o P=Daily Production / Output Level of Home Base Industry
  - o C=Daily Consumption rate
  - o X=Number of Consumers

Consider Battle Damage Munitions separately

Call it the **Equilibrium Methodology**

15

Assumptions

- Consider situation with longest deployment distances
- Assume national strategic lift is finite
- Assume units will bring combat load with them, i.e. supplies that will be consumed in first e.g. 7 days
- Assume that industrial and market mechanisms are leveraged in home base
- Assume that a re-supply cycle can be established
- Take SDOS as the daily consumption rate
- Assume lead-times for industry to start production of the supply item thus necessitating armed forces to maintain stock levels for an initial period

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First Conclusions

- The amount of supplies combat ready forces need to have on hand depend on
  - Number of days unit needs to 'settle in' before regular supply lines are set up; for that rules such as 7 days of combat ready supplies are created
  - Number of days that the transportation of supplies lag behind the deployment of the force; the debarkation of military units at the SPOD/APOD and their onward movement will have a higher priority than the transportation of supplies to the forward supply points
- The re-supply cycle packages supplies in such a way that the force is sustained for the period until the next package arrives:
  - Packages will be in bulk and boost the supply levels which will then gradually diminish, i.e. Stock levels follow a typical saw-tooth pattern
- Only a small portion of national units are in high readiness and industrial production can easily anticipate or catch up for units in FLR or LTBF

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Simple Model

- P is daily production level of class Z of supply
- C is daily consumption rate
- X is number of consumers
- P=C*X
- T_0= time in days for which the unit needs to take supplies to theater before re-supply arrives
- T_1= time in days for production line to be set up to reach output level of P
- T_2 = the number of days of supply that is in a package of re-supply
- N = number of re-supply cycles before production catches up with consumption

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Number of Cases

- $T_1 < T_0$: The production level in civilian market is adequate to provide consumption levels immediately
  - Shipment of unit and re-supply package are happening at the same time
  - Unit can use combat ready supply and then get re-supply immediately
  - Examples: food and water (some exceptions with fresh food)
- $T_0 < T_1 < T_0+T_2$: The production level is providing enough for consumption after the combat ready supplies are exhausted and before the first re-supply cycle time has passed
  - Additional stock level to overcome first re-supply cycle time
  - E.g. T_0=10 days and T_2=14 days; if production reaches level P after 10 days but before 24 days, then we need stock for 10+14=24 days.
- $T_0 +N*T_2 < T_1 < T_0+(N+1)*T_2$: The production level reaches consumption level equilibrium only after N cycles of re-supply

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Conclusions

- From the formula

$$T_0 + N{*}T_2 < T_1 < T_0 + (N+1){*}T_2$$

  we derive that re-supply cycle time T_2 is of little importance to determine time T_1, the time when production levels reaches consumption level equilibrium
- The most important parameter is T_1 the time that production will catch up with demand, demand that is generated only by consumers that are deployed
- And that stock levels for future consumers can come from production that is sufficiently early started, and therefore these stocks need not to be maintained

20

Impact

- Some classes of supply are immediately available from the civilian market and industrial base and therefore there is no need to stock these items
- While some other classes of supply may have a lead-time for production to be set up or catch up with the demand, and therefore stock levels are necessary, it will only be required to have those stock levels for High Readiness units
- However, munitions typically have a very long lead-time for production, leading to a requirement to have stocks available for much more than one re-supply cycle and beyond the original MC 55/3 30-days SDOS

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A.5.5 Intra-Theatre Airlift

(See Application Area 2 – Section A.2.3)

A.6 SCHEDULING

A.6.1 Replenishment at Sea Scheduling

(See Application Area 5 – Section A.5.2)

A.6.2 Out-Planning

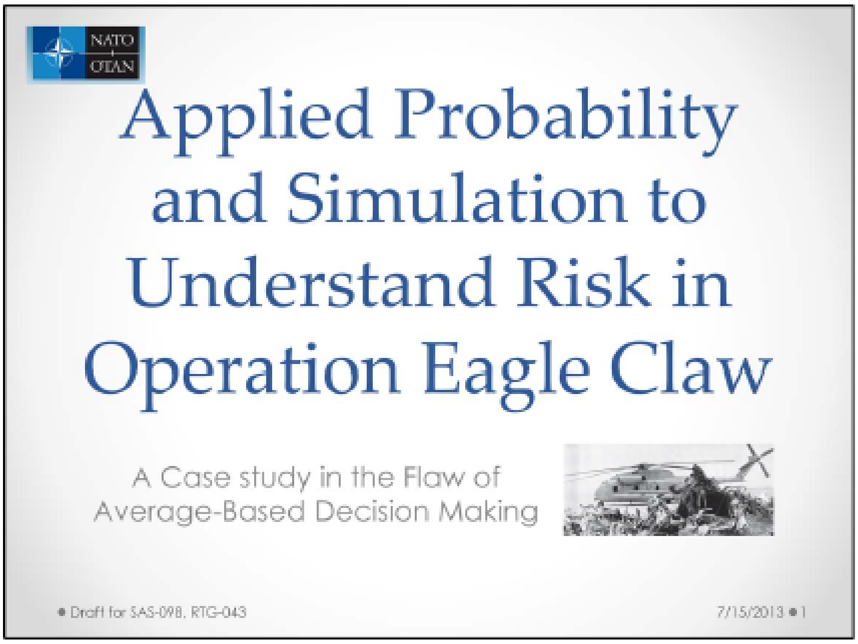
(See Application Area 5 – Section A.5.3)

A.7 OTHER

A.7.1 Quantitative Risk Assessment: Operation Eagle Claw

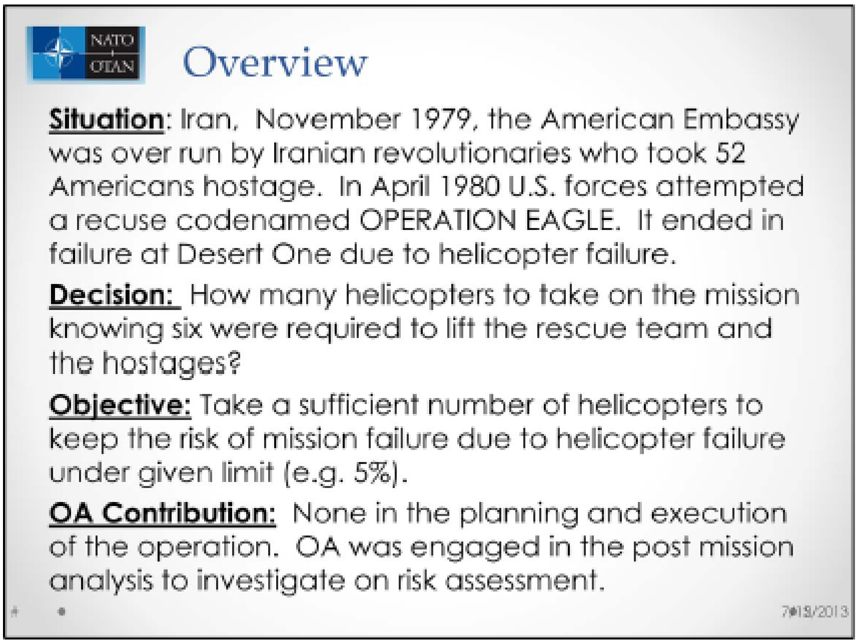
INSTRUCTIONAL MODULE SUMMARY

Title	Quantitative Risk Assessment: It's All About the Variability
Faculty Name(s)	Jeff Kline, Naval Postgraduate School, Monterey, California, USA
Length	20 – 30 minutes
Learning Objectives	Understand the relationship between quantitative risk assessment, variability, and uncertainty. Appreciate the dangers of average-based decision-making. Appreciate the strengths and weakness in simulation-based risk assessment.
Outcomes	As the result of this module, participants will be able to: Appreciate the sources of variability and relationship to risk. Understand the shortcomings of average-based decision-making. Read an "S" curve to provide risk given a level of resource.
Content Outline	Case Study: Operation Eagle Claw. Average-based decision-making examples. Case Study: Gas Turbine rework facility budgeting. Surprise and Black Swans. Recommend Readings.
Materials	List Required Pre-Readings: Savage, S., "The Flaw of Averages: Why we Underestimate Risk in the Face of Uncertainty", John Wiley & Sons Inc., Hoboken, New Jersey, ISBN 978-0-471-38197-6, 2009.
Methods	80% Lecture 20% Class Discussion. ____% Break Outs.
Exercise(s)	Seminar participants will be asked to evaluate charts and outputs from each case study.
Break Outs	___ Yes X No. __#___ participants in each break out group.
Discussion Questions	In your experience, where is average-based decision-making used most in your organization? How can variability be taken into account while planning operations?

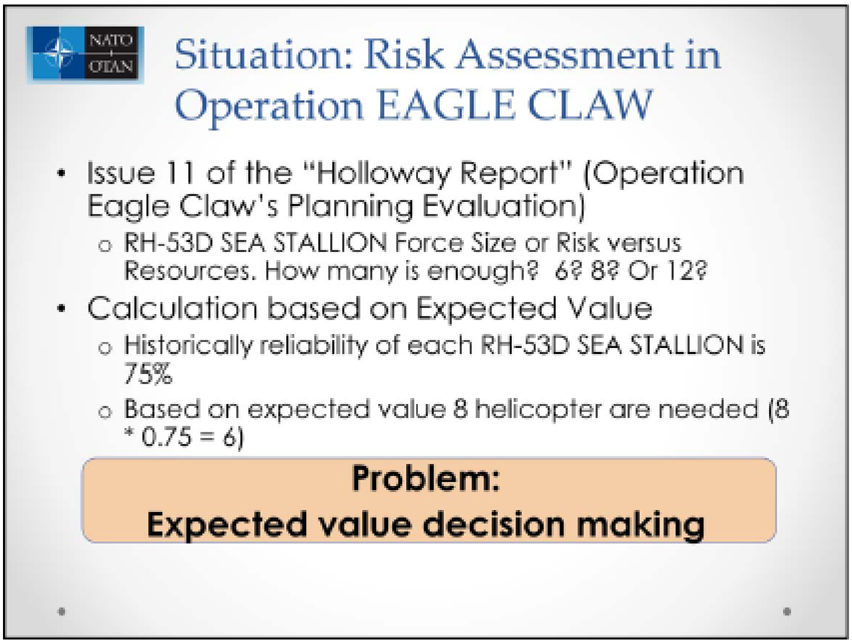


Slide one: Introduce subject and instructor

This case study deals with an application of operational analysis, risk assessment, that was not done but according to a United States Admiral should have been done. We look back to late 1979 when Iranian demonstrators took over the American Embassy.

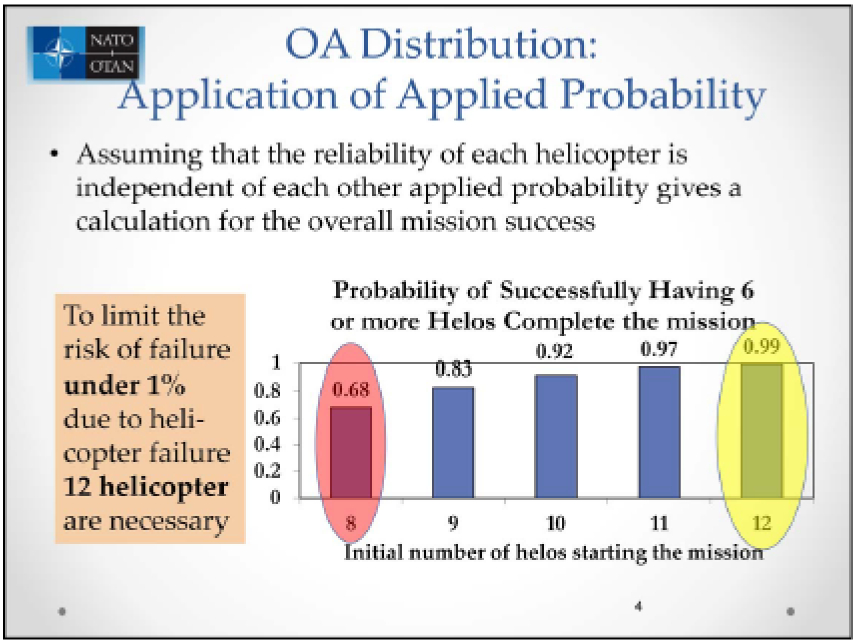


Here is the overview and situation. After five months of captivity, President Carter ordered a rescue attempt of the Americans being held by Iranian forces inside the American Embassy. That attempt failed due to a catastrophic accident that occurred at a desert refueling site called Desert One. The post investigation uncovered several planning challenges but the one we will focus on is the decision on how many helicopters to use in the mission. To lift all the U.S. forces and return with all the hostages a total of six helicopters were required to make the round trip. The issue for the original planning team was how many helicopters to send to account for helicopter failures. As we will see, the planning team just used a form of average-based decision making and did not apply some simple risk assessment tools to give them an assessment of possible overall mission failure due to helicopter reliability.



Slide 3:

After the Iranian Rescue mission failure, a follow on investigation lead by Admiral Holloway uncovered several challenges to the planning and execution of this operation. His report lead to the establishment of the U.S. Special Operations Command.
Our interest is Issue number 11 from the report: The way the number of RH-53Ds readied for the mission was determined based on an expected value of individual failure. In this case it was 75%. The planners simply solved the equation X * .75 = 6 to determine they needed to start with 8 helicopters. The average based decision method does not take into account the "tails" of probability of success or failure. It places you somewhere in the middle of the chances of succeeding or failing.

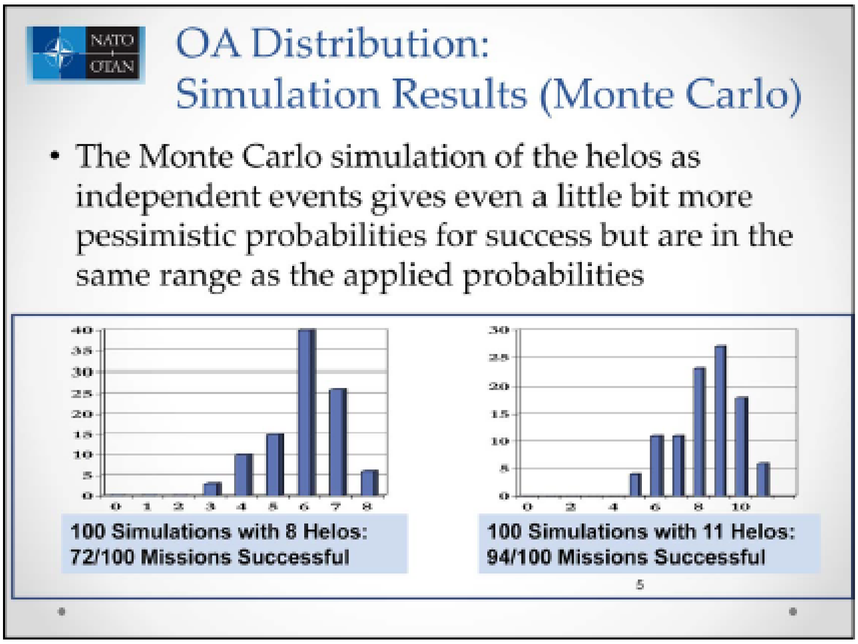


Slide 4:
Instructor notes:

Explain what a binomial distribution is by using a simple example:
--3 heads out of five coin tosses
--Or in this case 6 or more heads out of how many coin tosses I need for a certain level of success
Discuss independence assumption on each trial and how it this case it is false (helos flying in formation are not independent), but this method still gives one a gross level assessment of risk of failure.

What can be seen is more resources: less risk of failure

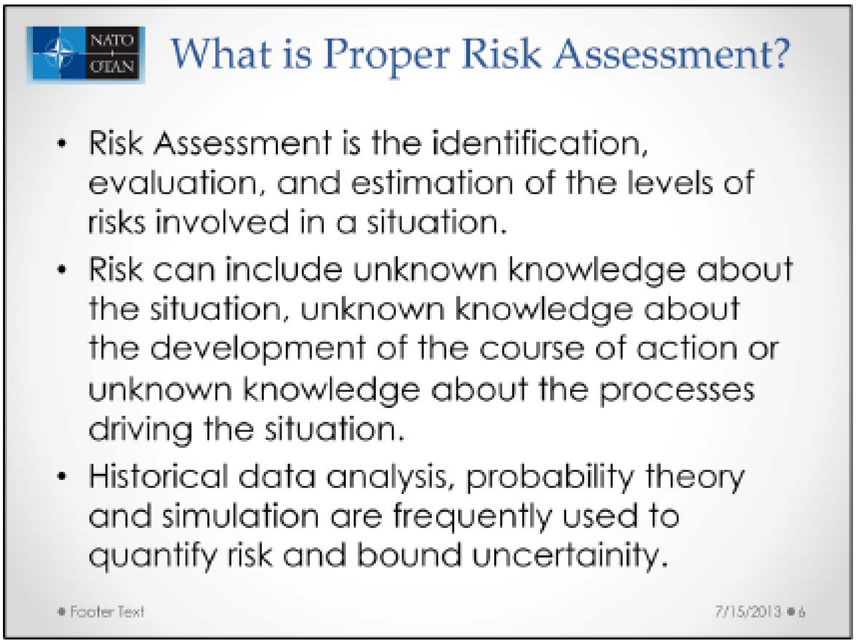
Point out the end of a risk curve or S curve: more on that later.



Slide 5:

Simulation is another approach and can mitigate independence assumption. In this case we simulate the round trip mission and record the number of helos surviving after each mission.

Use point to explain a frequency plot that provide a histogram



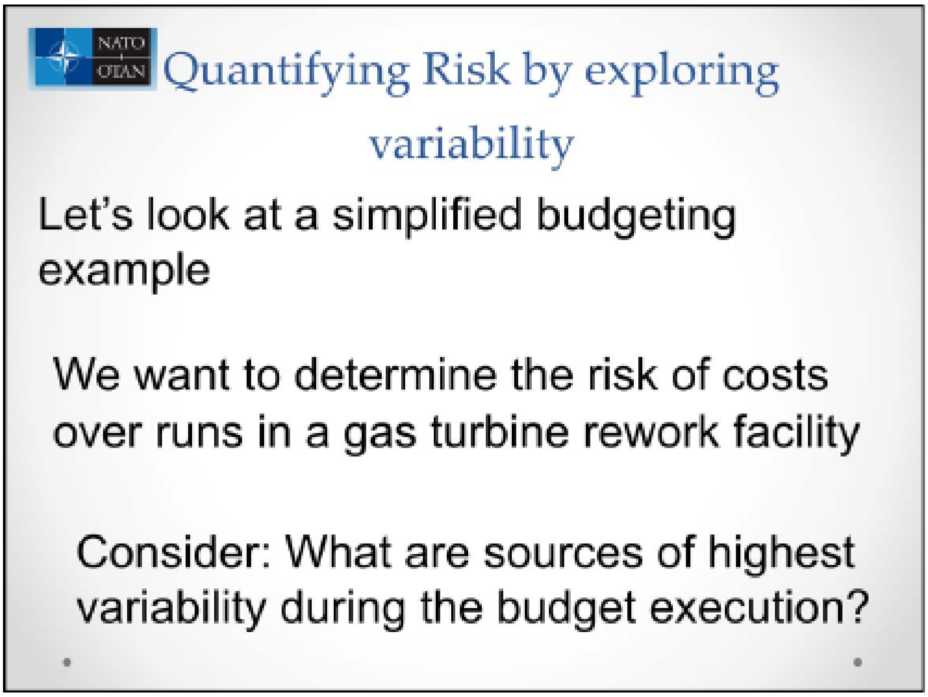
Strengths and Weaknesses Risk Assessment

- Provides insight into marginal benefit of resources to lessen risk.
- The better the historical date base and/or estimates, the better the assessment value.
- In many cases, assumes environment in the immediate future will be the same as the immediate past for data consistency.

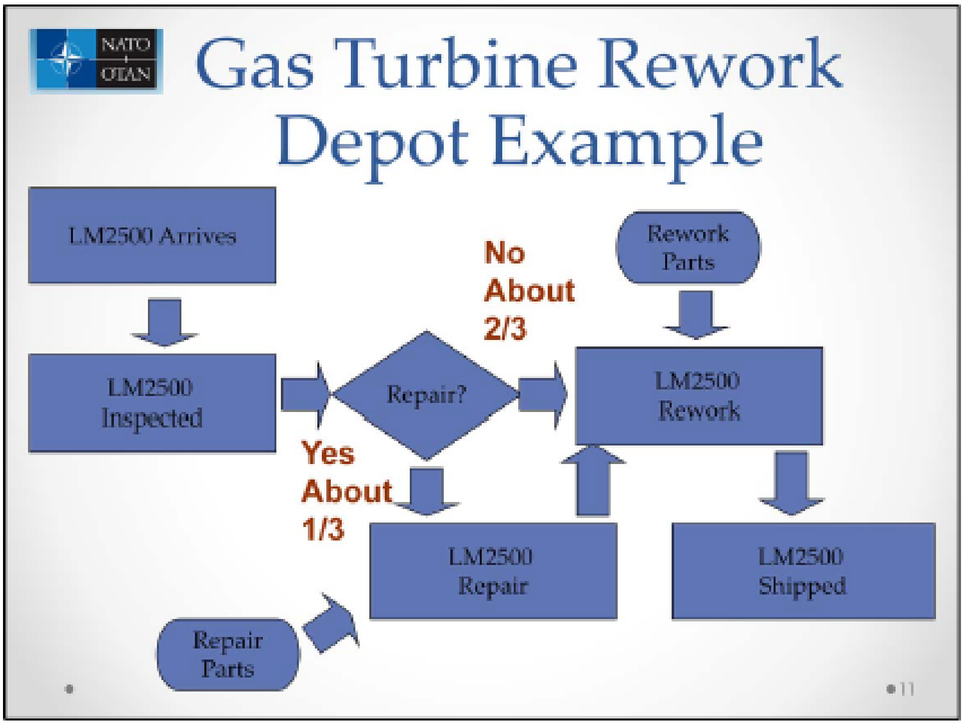
Summary

- Risk analysis is driven by you, the decision maker. You define what is an acceptable risk.
- To best utilize your operational analyst to aid in decision making, they need access to you, the decision maker to know about your preferences and to be involved as well in the planning process as during execution.
- The operational analyst brings a variety of tools (optimization, simulation, statistics, and assessment skills) to help you with evidence based decision making.

8

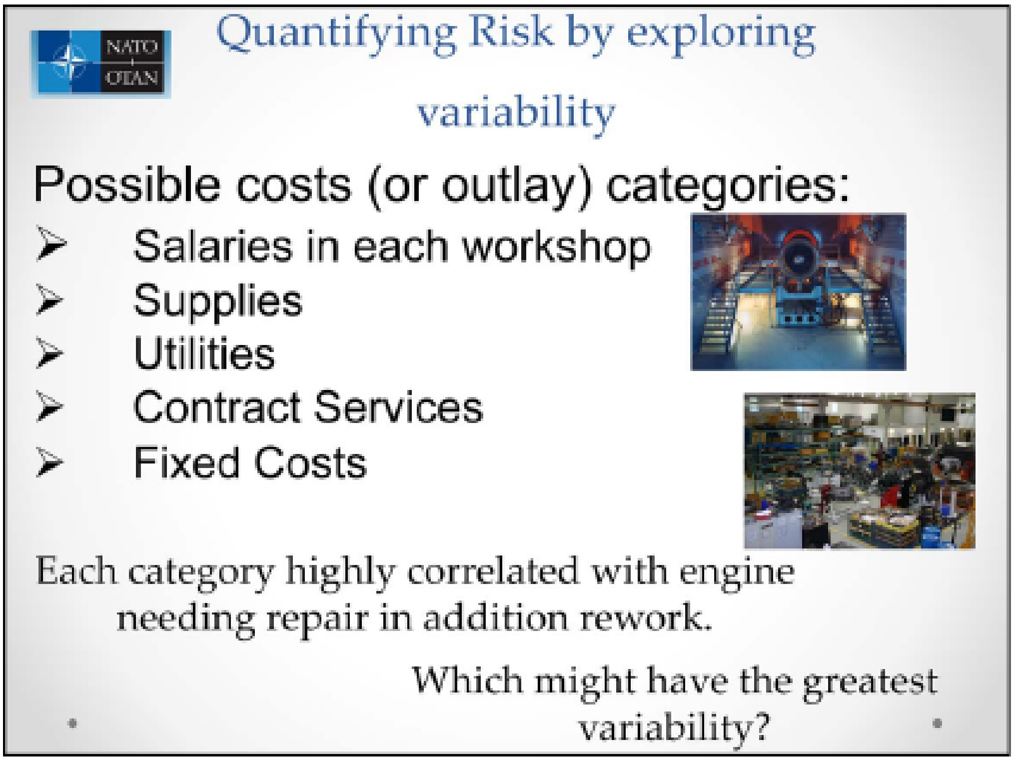


Slide 10:
Let’s move from the case study to another example of how one can use risk assessmsent. Let’s apply this concept to a budgeting forecast where we are budgeting for rework of 30 gas turbine engines over three months.
Although we will use a rework example, the U.S. Navy uses the same process for understand the risk in budgeting for ship construction.



Slide 11:

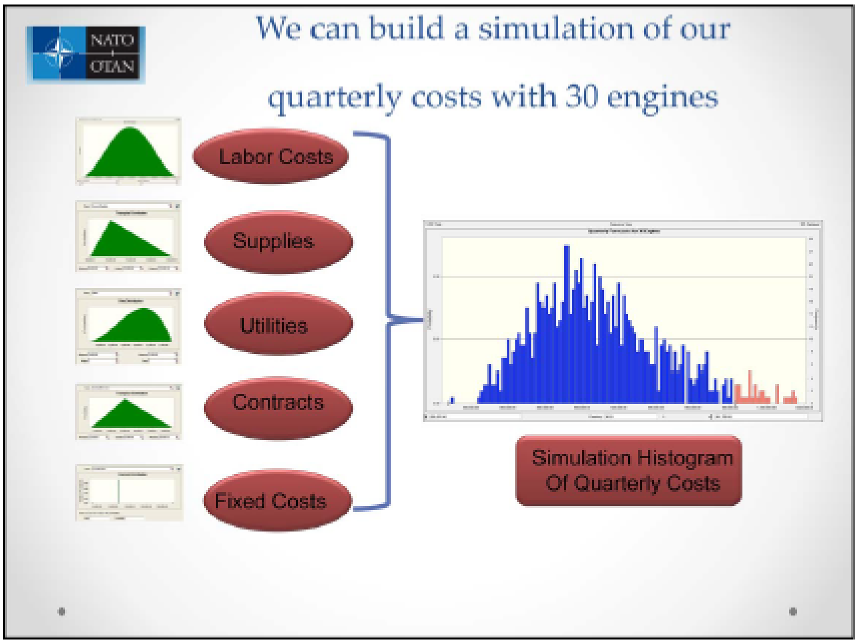
Explain flow of work in the rework depot and "cost" centers. Ask seminar where they think the most "cost" variance is. Discuss we expect that to be in the repair shop.



Slide 12:

Explain where cost can occur in our example:

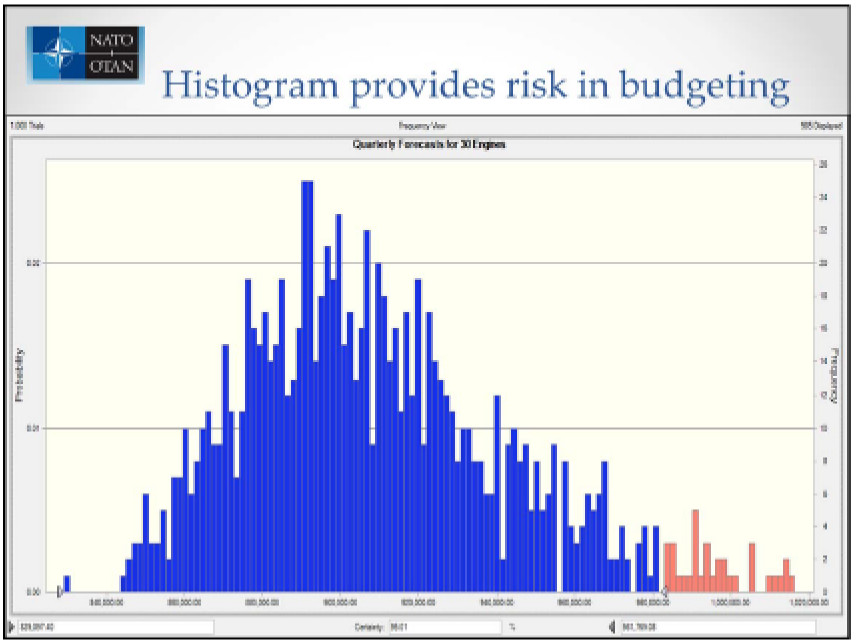
- Salaries in each workshop
- Supplies
- Utilities
- Contract Services
- Fixed Costs



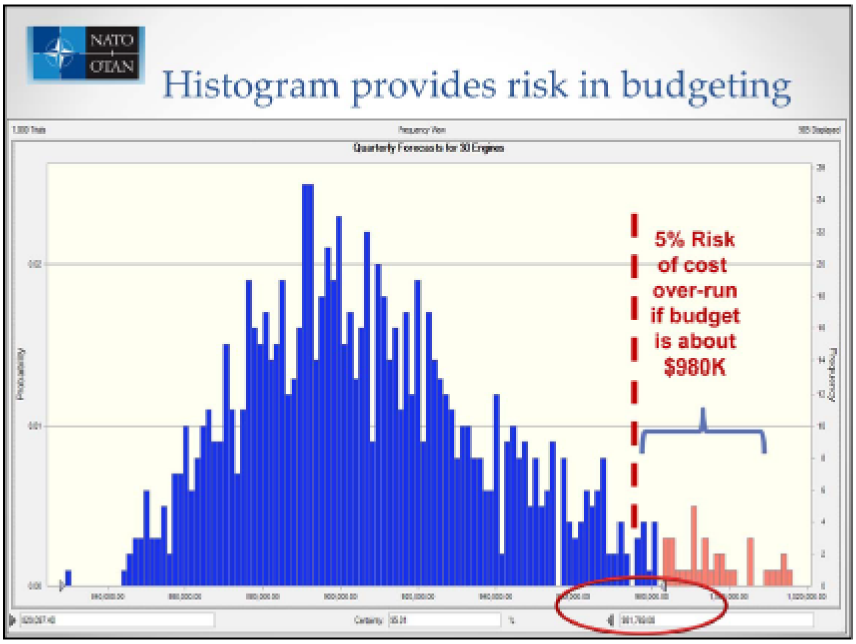
Slide 13:

Discuss where we get the data distributions: historical analysis from past cost performance (best), subject matter expert experience (fair), no information (guess). In our example, we use historical data to draw upon to simulate the process. We do this to get a "combined" distribution of total costs. Point out this can be done without simulation if past data for total costs are available.

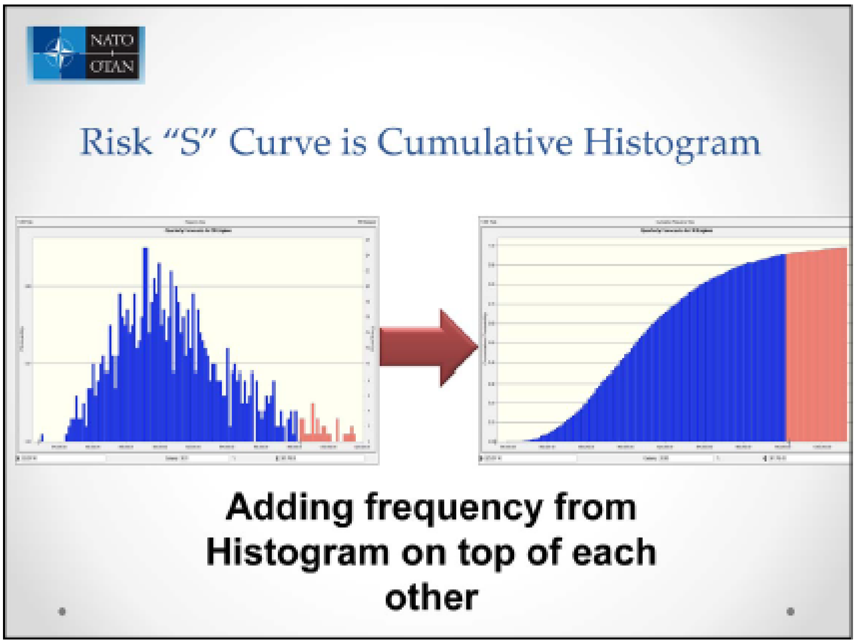
Point out this picture can be of any process that include variability from each step. For example, recall the U.S. Navy uses this technique for ship cost budgeting. Each input distribution are categories like cost of copper, steal, labor, schedule slippage, etc.



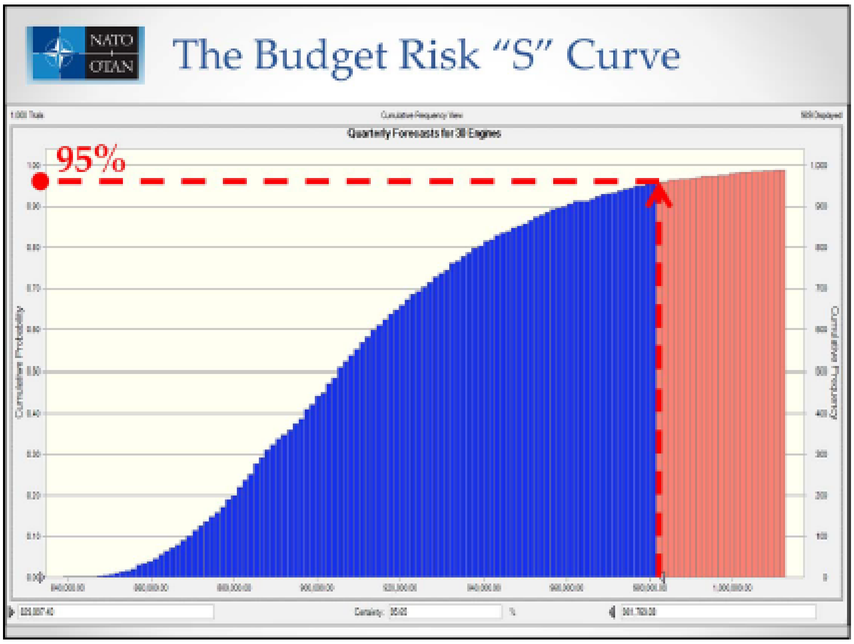
Slide 14:
Closer look at the histogram of results simulating 1000 quarters of 30 engine repairs. Explain points on histogram



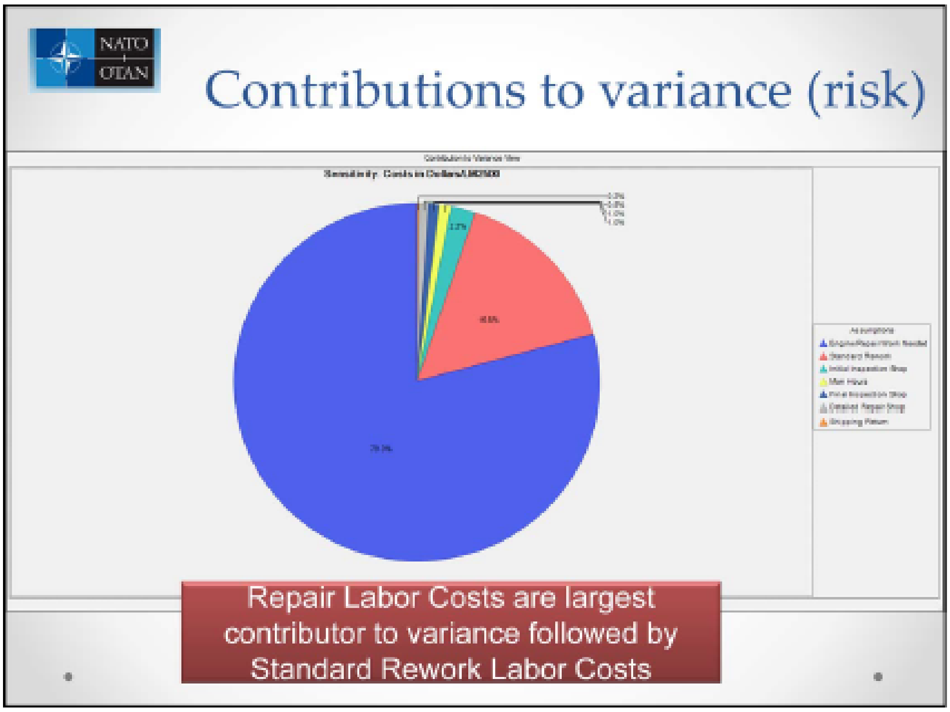
Slide 15:
The histogram allows us to conduct "what ifs". What if I budget $980K for the coming quarter to conduct 30 engine reworks? Then, based on my historical data and simulation, I'll have about a 5% chance of being under budgeted.



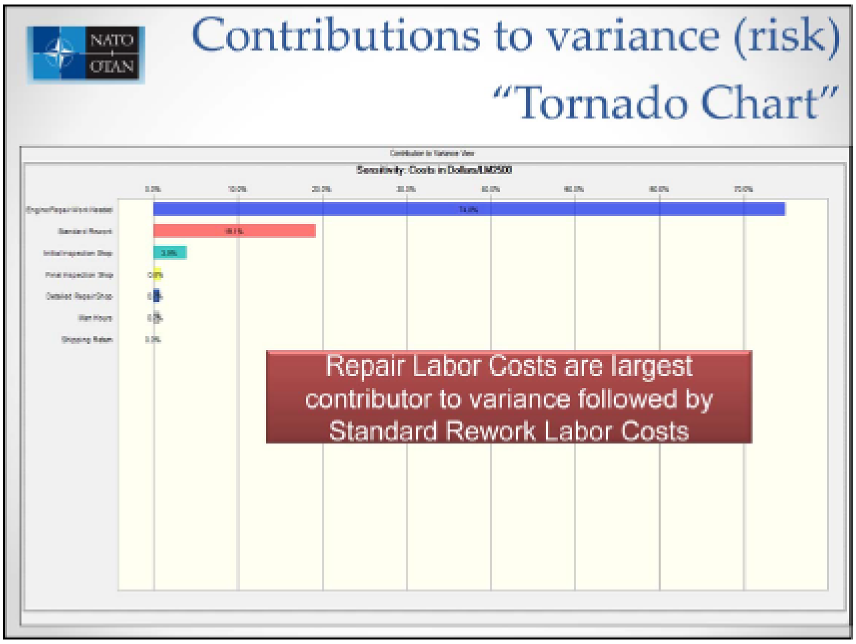
Slide 16:
Risk analysts like to convert the frequency results into S curves for ease of reading. Explain a S curve is just the cumulative distribution.



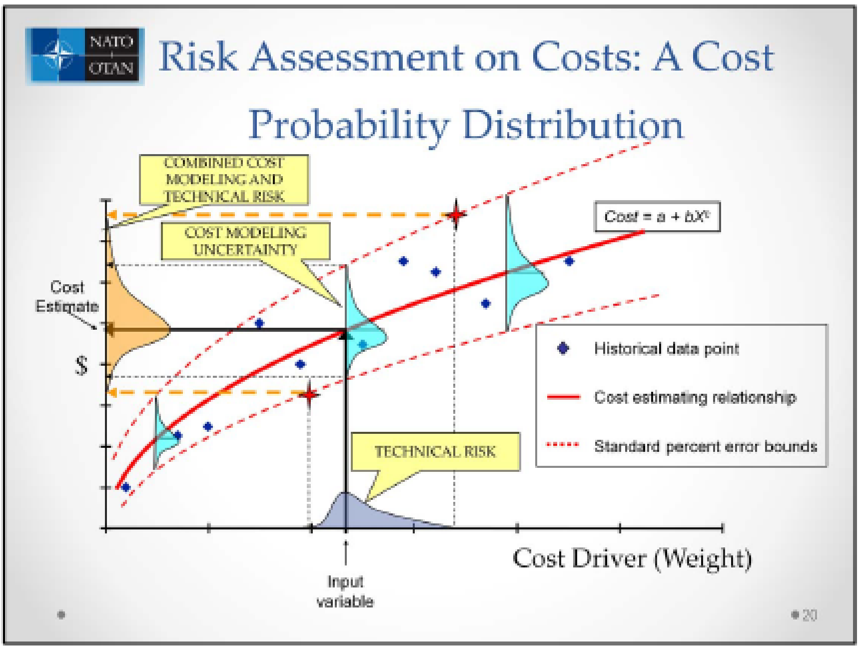
Slide 17:
With an "S" curve, I can read my risk of being on or under budget directly from the y axis. What if we are only given $900K to rework the 30 engines? What are our chances we will be over budget? Ask the seminar what we can do about it. Fewer engines?



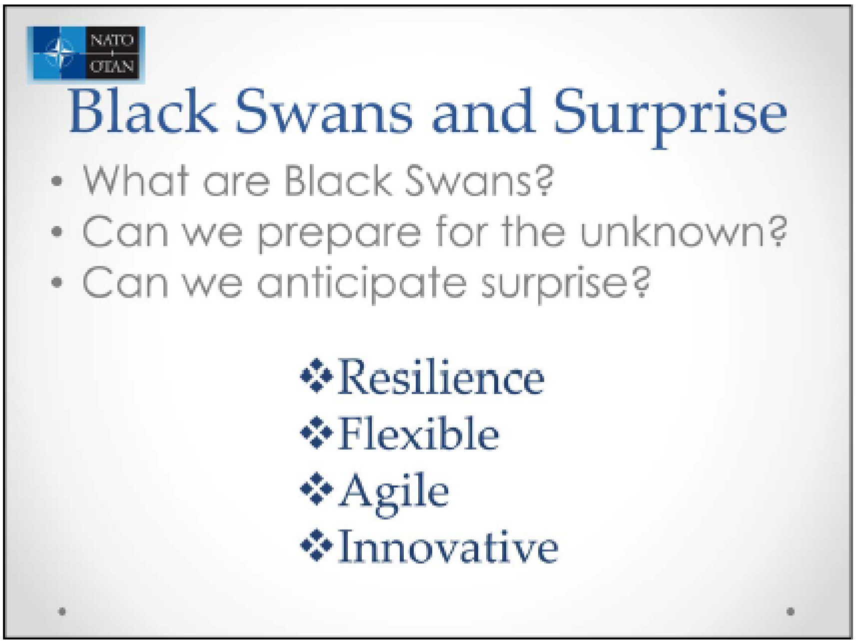
Slide 18:
Simulation results can also provide where your variability comes from. In this chart, we see the most variability comes from the repair shop labor costs (as expected since we don't know in advance what repairs are needed). The second most variability (almost 16%) comes from the standard rework shop. Ask the seminar if this makes sense, or do we need to look at the reasons.



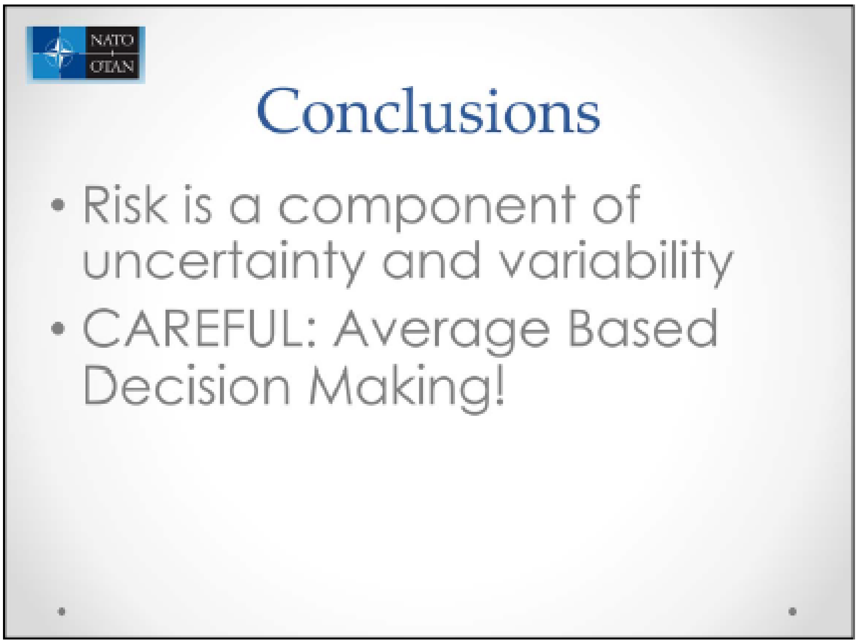
Slide 19:
Contributions to variance are frequently shown as tornado charts. They provide the same information in a bar format and are preferred by many decision makers.



Slide 20:
The concept of variance and risk can be found in many analytical methods. This is a cost estimation slide using regression to estimate future program costs, and you can see the variance of the estimates come from variance of the input information.



Slide 21:
But, what about preparing for events we don't plan for or anticipate? We cannot analyze or simulate that which we don't anticipate. Discuss concept of Black Swains and surprise, red teaming, and response. Allow seminar to bring up examples.



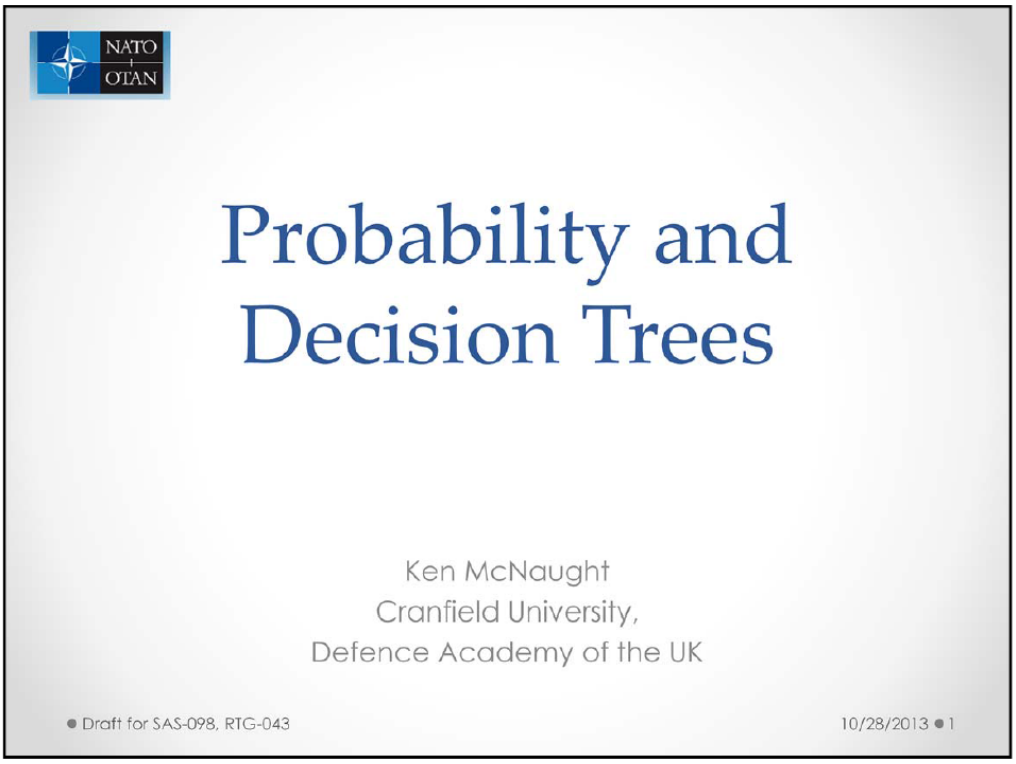
Slide 22:
Conclusions. Review major points on uncertainty and variability.

Slide 23:
Recommended readings:
Against the Gods
Failure of Risk Management
The Flaws of Averages.

A.7.2 Decision Trees

INSTRUCTIONAL MODULE SUMMARY

Title	Accounting for Uncertainty in Operational Planning – Probability and Decision Trees
Faculty Name(s)	Ken McNaught, Cranfield University
Length	60 – 90 minutes
Learning Objectives	Understand the importance and role of probability and decision trees to aid operational planning. Understand the difference between objective and subjective probability and how probability represents uncertainty. Understand the difference between an outcome measurement and its utility. Know how to structure a decision tree to help choose between alternative actions in the face of uncertainty.
Outcomes	As a result of this module, participants will be able to: Appreciate the value of probability and decision trees. Understand the difference between objective and subjective probability.
Content Outline	Example probability trees involving objective and subjective probabilities, e.g. calculation of mission success.
Materials	List of Required Pre-Reading: Ideally Ch 2 on basic probability in Goodwin and Wright's Decision Analysis for Management Judgment, but not essential.
Methods	60% Lecture 20% Class Exercises. ___20_% Break Outs.
Exercise(s)	Seminar participants will be asked to provide subjective estimates for various probabilities and utilities; use these to construct and solve a decision tree, and to recognize where the limits of the approach lie.
Break Outs	___ Yes. __3-5___ participants in each break out group.
Discussion Questions	Validity of subjective probabilities, bounded rationality of human decision-makers, everyday examples of non-linear utilities.



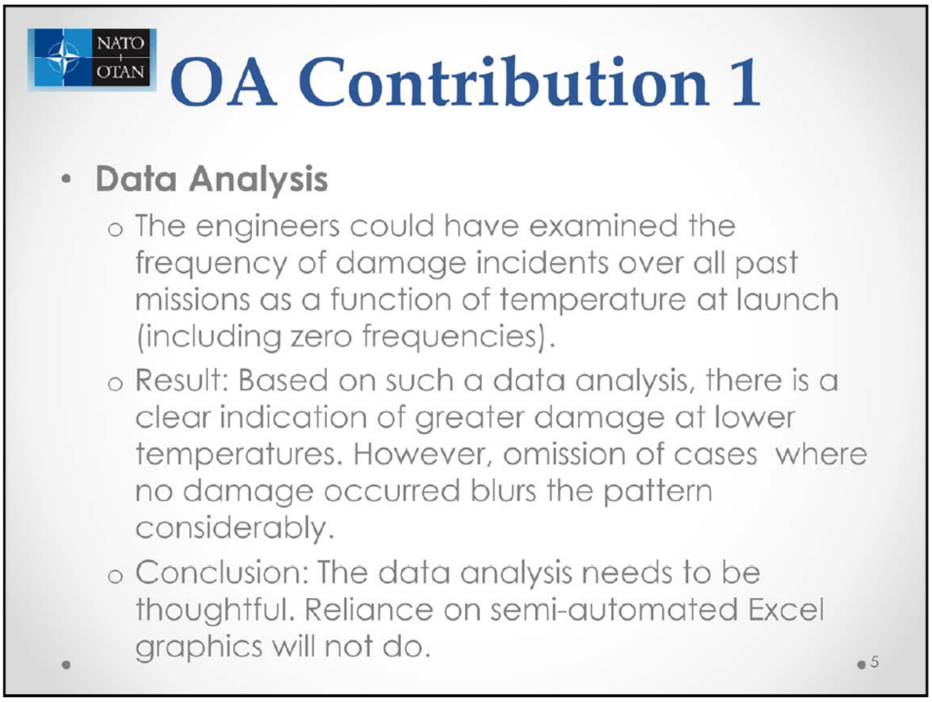
This provides an example of the dangers of relying on gut instinct, rather than conducting a quick but logical analysis.

Situation

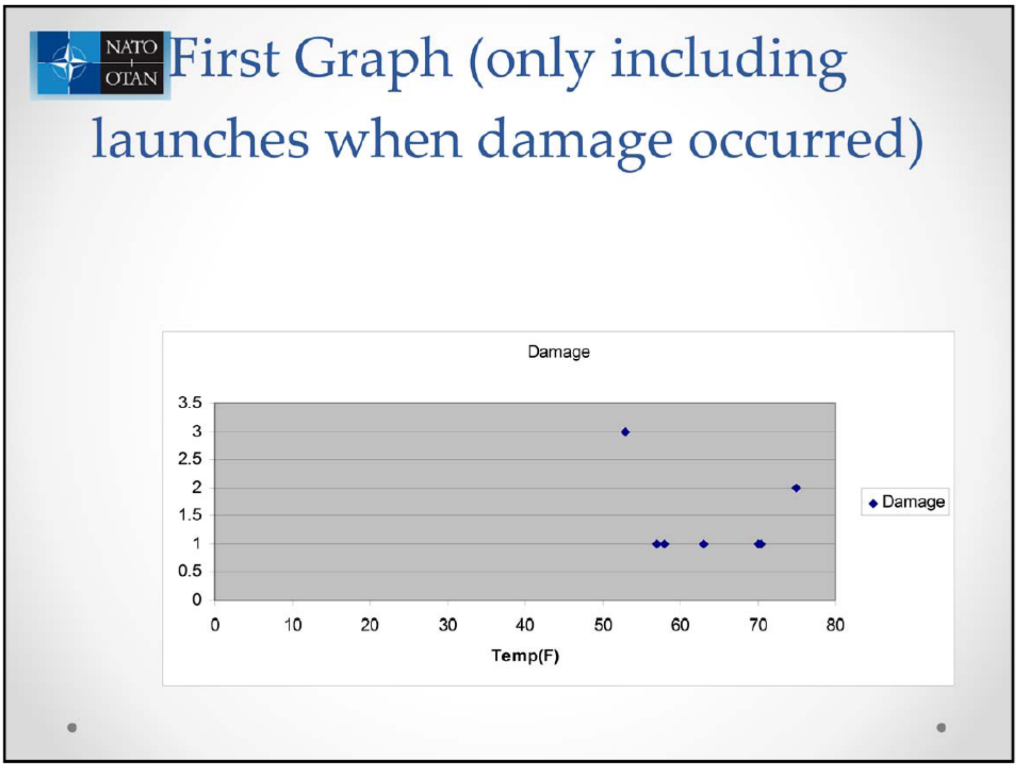
- On 28 January, 1986, the Challenger Space Shuttle was scheduled to launch.
- Temperatures had reached a 100-year low. The morning of the launch saw freezing temperatures of 29F.

The Problem

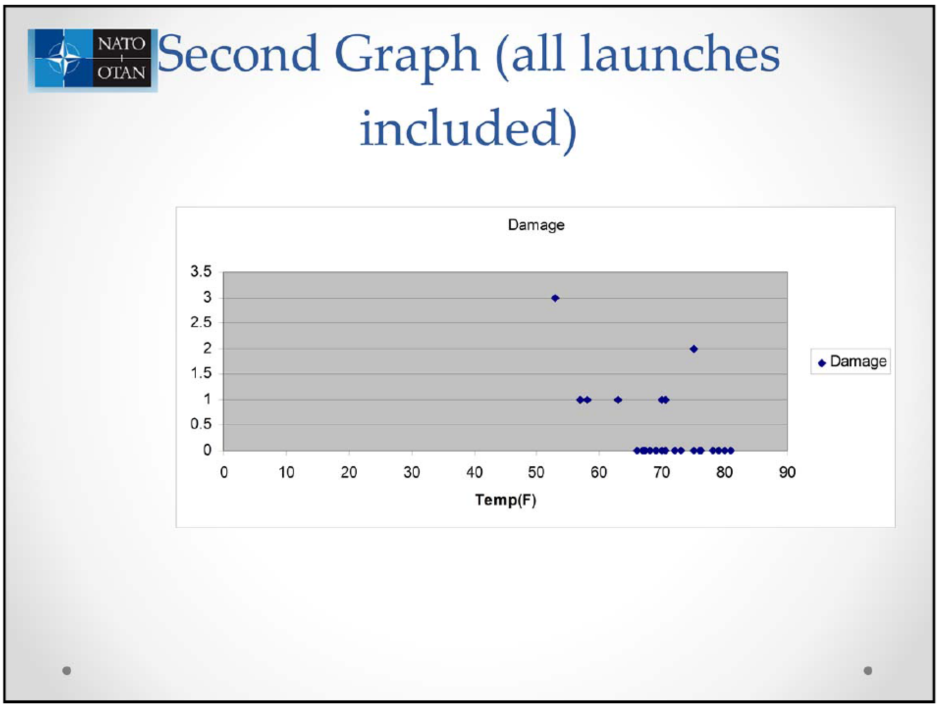
- The supplier of O-rings for the solid rocket booster (SRB) joints feared that they would not seal effectively at low temperatures and the night before, advised against launching.
- NASA requested them to offer proof of the problem. Despite heated arguments within the supplier, the supplier's management eventually decided that they did not have the proof requested.



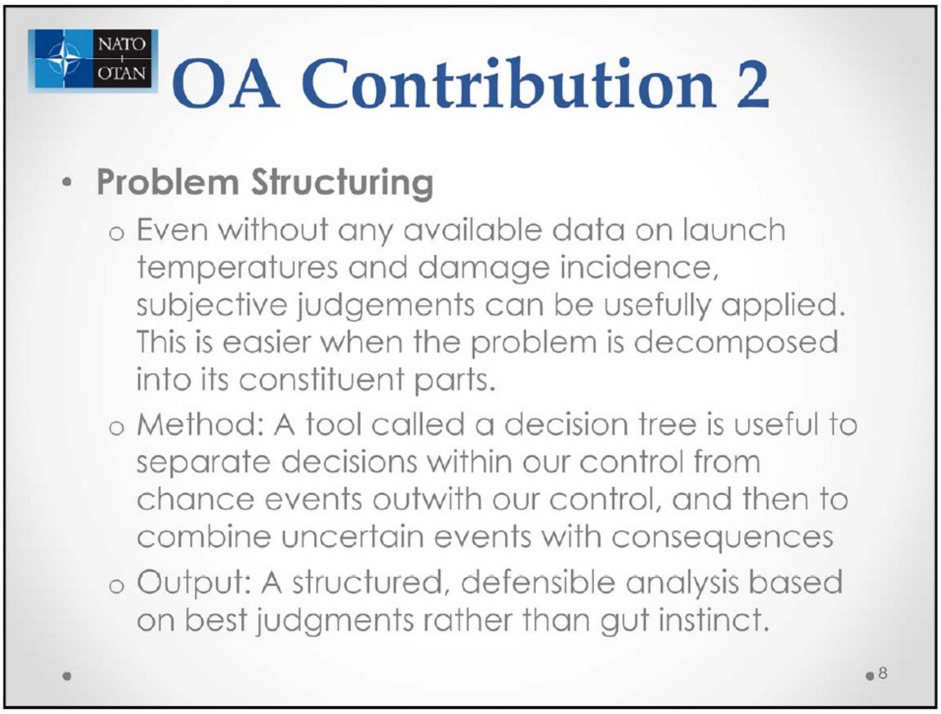
Although temperature was known to be a problem for the O-rings, it appears that the engineers did not consider plotting level of damage vs temperature. However, even if they had, they would have had to include incidences of zero damage for the graph to be useful.

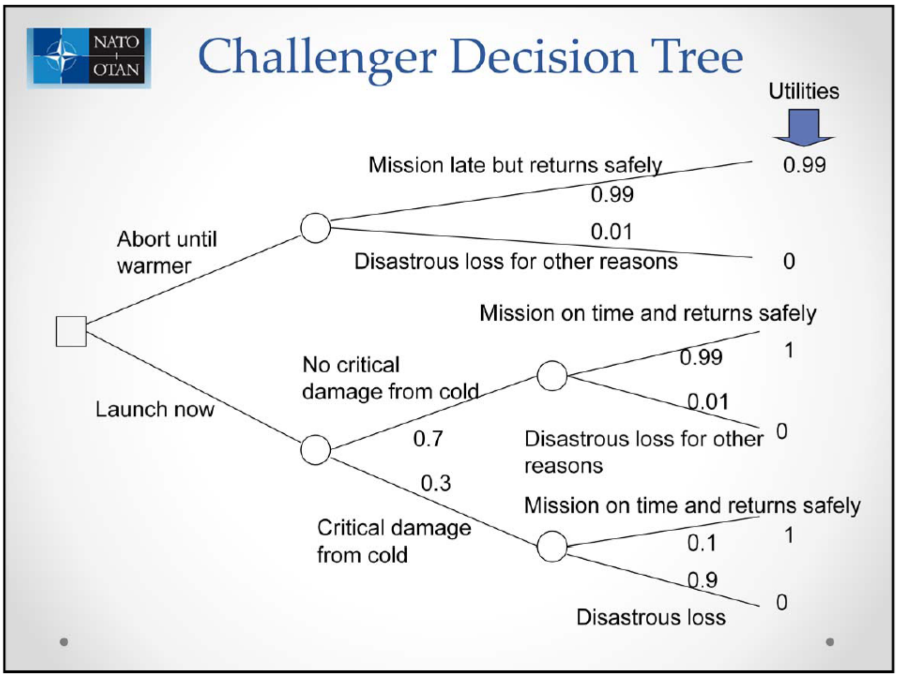


No obvious pattern given the relatively few points plotted.



The pattern of more damage tending to occur at lower temperatures is much clearer in this graph. By including all of the launches, we see that most of the higher temperature launches suffer no damage.





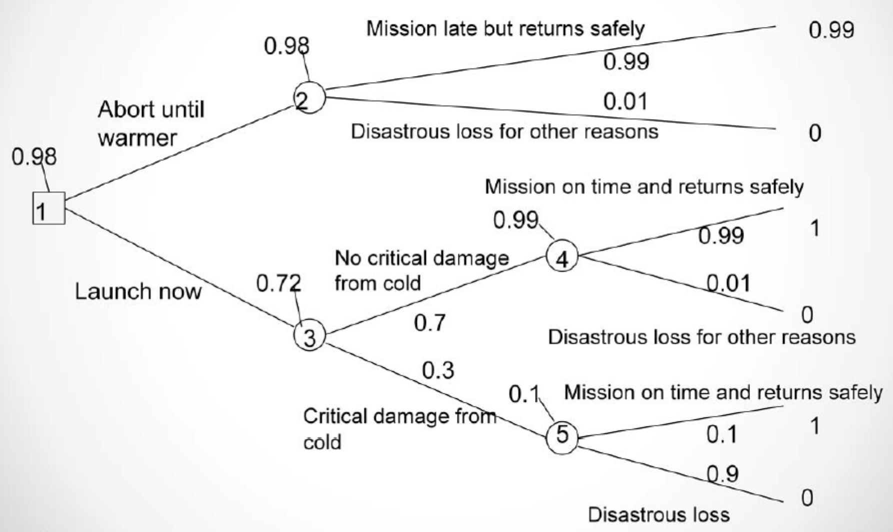
These assessments are subjective but if anyone queries them, the analysis can be done with their preferred assessments instead. The result is likely to be similar unless some very odd judgments are made. The assigned subjective probability of 0.3 for the occurrence of critical damage from cold weather is deliberately optimistic to try and reflect the optimistic bias that existed pre-launch. Even this optimistic judgment, however, still results in a recommendation not to launch. The suggested utility of 0.99 for a mission being late but returning safely may also be questioned. The group then has to consider how many late but safe missions they would trade off to avoid one disaster. The utility would have to drop to about 0.73 to reach the break-even point. Would anyone seriously think that the drop in utility from an on-time and safe mission was as much as a quarter of the drop in utility from an on-time and safe mission to the disastrous loss outcome?

Solving the Tree

- Assume that the payoffs shown at the right of the tree represent our values or utilities for the various outcomes.
- The usual objective in such situations is to maximize the so-called expected value which is actually just a weighted sum, with the weights corresponding to the estimated probabilities of the various outcomes.
- The expected value at each chance node is calculated, e.g. at node 2, it is (0.99 x 0.99) + (0.01 x 0) = 0.98 to 2 d.p.
- Similarly, at nodes 4 and 5, the expected values are 0.99 and 0.1, respectively
- Rolling back to chance node 3, the expected value is (0.7 x 0.99) + (0.3 x 0.1) = 0.72.
- Finally, rolling back to decision node 1, we would choose the branch which maximized the expected value, i.e. the Abort action with an expected value of 0.98.

May need to explain the statistical concept of expectation, which is really just a weighted average. Look out for anyone being mislead by the literal meaning of 'expected' which is obviously different to the statistical meaning.

Solving the Decision Tree



OA Contribution

Defusing the Argument with Sensitivity Analysis

- The tree clearly shows that aborting the launch until warmer should be the preferred decision.
- However, we can also calculate how low the unknown probability of sustaining critical damage due to the cold has to be before that best decision changes.
- In this case, with the value judgements assumed, it has to be as low as 0.01 or 1% before continuing with the launch becomes the preferred alternative.
- Given the degree of uncertainty surrounding the O rings' ability to seal at such low temperatures, highlighted by the manufacturer's initial recommendation not to launch, such a low probability is not credible

OA Contribution

Providing Evidence

- **Outcome**

  NASA decided to go ahead with the launch. 73 seconds into the flight, one of the SRBs exploded, and the crew cabin detached, hitting the ocean three minutes later and killing everyone onboard.

CONCLUSION: Despite the various uncertainties, a structured analysis of the situation was possible and could have avoided the disaster.

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Summary

- Without thoughtful structuring of a problem as provided by OA, there often seems no alternative but to rely on gut instinct.
- To best utilize your OAs to aid in decision making, they need access to you, the decision maker.
- The OA brings a variety of tools like optimization, simulation, statistics (e.g. hypothesis testing), and assessment skills to help you with evidence based decision making.

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Learning Objectives

- To understand the difference between objective and subjective probability
- To understand the difference between an outcome measurement and its value or utility
- To appreciate the role which probability and decision trees can play in aiding operational planning
- To know how to structure a decision tree to help choose between alternative actions in the face of uncertainty

Danger of Relying on Gut Instinct

- High-stakes situations demand cool, logical decision-making.
- Reducing a decision problem to its most important constituent parts and assessing values for each part individually:
  - reduces the chance of missing something important, and
  - combats the danger of being influenced by an inappropriate cognitive bias which can skew our thinking without us even being aware of it.
- A small decision tree can be assembled in minutes so providing an instant decision is not required, this could be a few minutes very well spent.

Requirements of a Decision Tree

- Judgments concerning the probabilities of uncertain outcomes:
  - Sometimes we will have hard data to help us estimate these
  - Sometimes we will have very little data and will need to rely on a subjective judgment
- Judgments regarding the relative worth of the different possible outcomes. These value judgments may be non-linear with respect to the measurement variable.

Probability

- The best method we have for quantifying and dealing with uncertainty.
- Measured on a scale from 0 to 1, where 0 means logically impossible and 1 means logically certain. Such extreme values should only be applied when the logical condition is met. If an event is possible, no matter how unlikely, it has a non-zero probability.
- The chance or probability of some event of interest occurring lies in this interval between 0 and 1, with the value of the probability indicating how likely the event is to occur.

Probability Properties

- If event A is more likely than even B, then
  - $P(A) > P(B)$
- If events A and B are equally likely, then
  - $P(A) = P(B)$
- If we can identify a set of events such that only one of them can be true, then they are said to be mutually exclusive, e.g. rolling a 1 or a 2 on a fair 6-sided die.
- For mutually exclusive events,
  - $P(A \text{ or } B) = P(A) + P(B)$
  - E.g. $P(\text{rolling } 1 \text{ or } 2) = P(1) + P(2) = 1/6 + 1/6 = 1/3$
- When the set of events is both mutually exclusive and exhaustive (covers every possible outcome), then the sum of probabilities over all the events adds up to 1.
  - E.g. $P(1 \text{ or } 2 \text{ or } 3 \text{ or } 4 \text{ or } 5 \text{ or } 6) = 1$

Probability Trees 1

- Probability trees (also sometimes called event trees) help us to visualise situations where several uncertain events are relevant, particularly if a sequence of events is being considered.
- Such trees are commonly used in risk analysis, where logical assessments of high-stakes situations are regularly required.

Probability Trees 2

- A probability tree provides an intuitive graphical representation of how chance events which depend on one another are related.
- Nodes represent uncertain propositions or chance events while the branches emanating from a node represent the possible resolutions of that proposition or the possible outcomes of that chance event.
- The branches emanating from any node have probabilities attached to them which must sum to 1, i.e. the outcomes represented by branches are mutually exclusive and exhaustive.

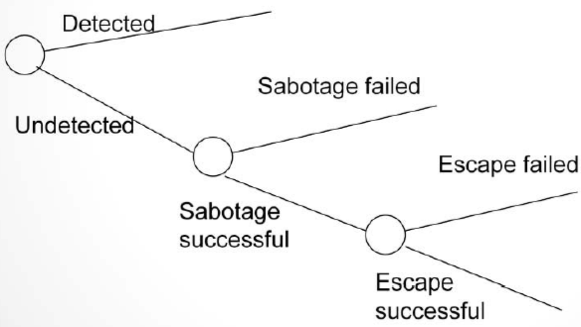
Probability Trees 3

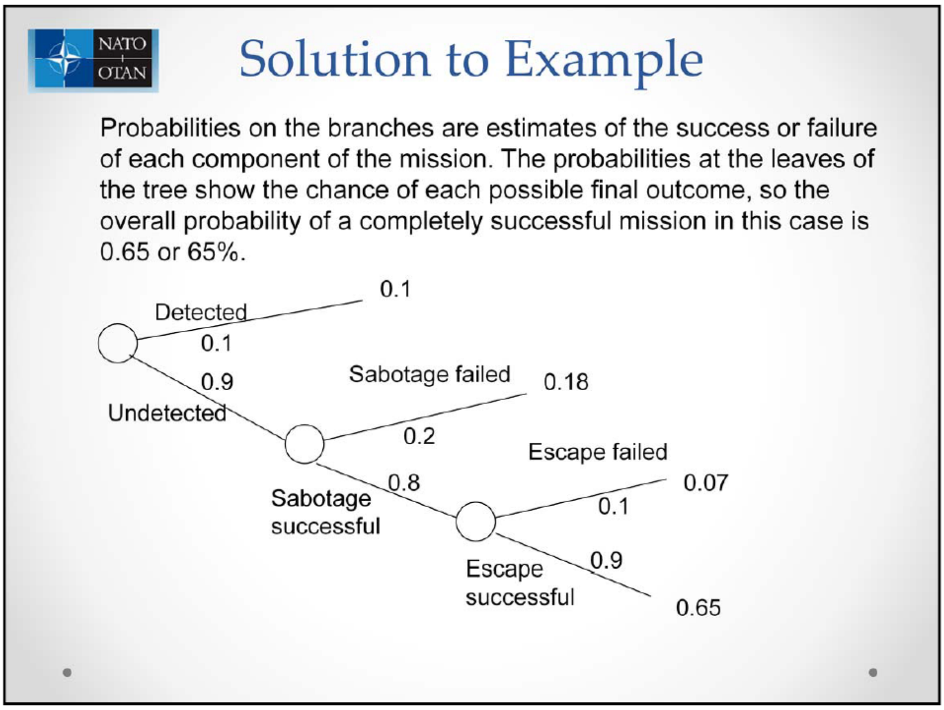
- The tree is conventionally drawn from left to right.
- The probabilities attached to the branches from the first node in the tree are marginal probabilities, not conditioned on any preceding event.
- Branches emanating from later nodes have conditional probabilities since these outcomes may be dependent or conditioned on the set of outcomes which have preceded them in the tree.

The convention is to order the nodes as much as possible according to the order in which information is revealed to the decision maker.

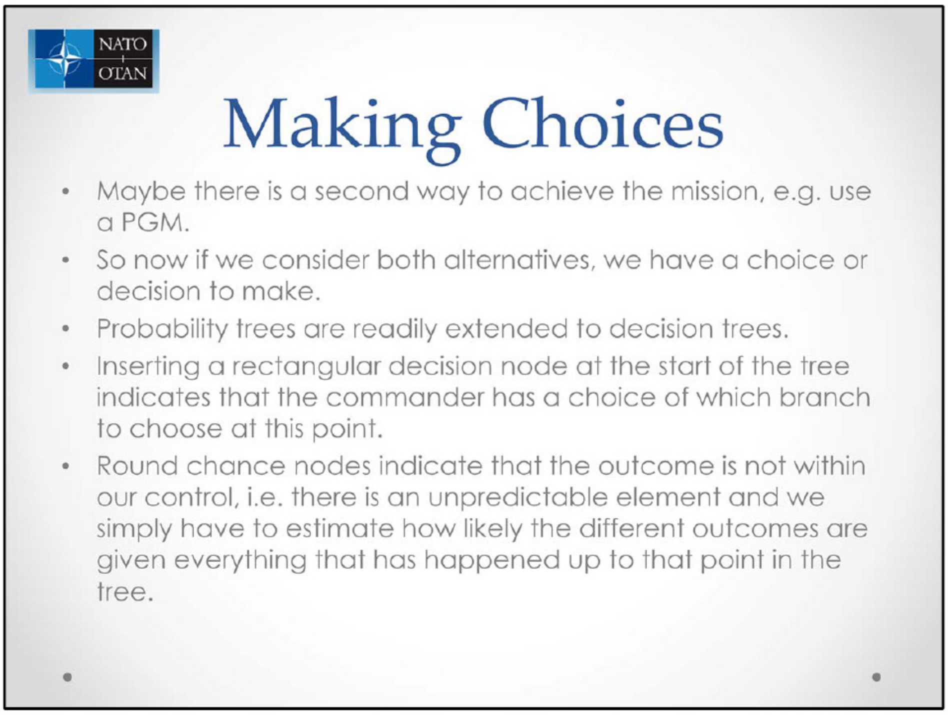
Example

- A mission involves inserting special forces undetected, having them conduct a sabotage operation at some facility and then escape undetected : estimate the chance of success.





P(Undetected) x P(Sabotage successful | Undetected) x P(Escape successful | Sabotage successful and Undetected) = 0.9 x 0.8 x 0.9 = 0.65 to 2 d.p. Course participants may suggest their own values for any envisaged scenario.

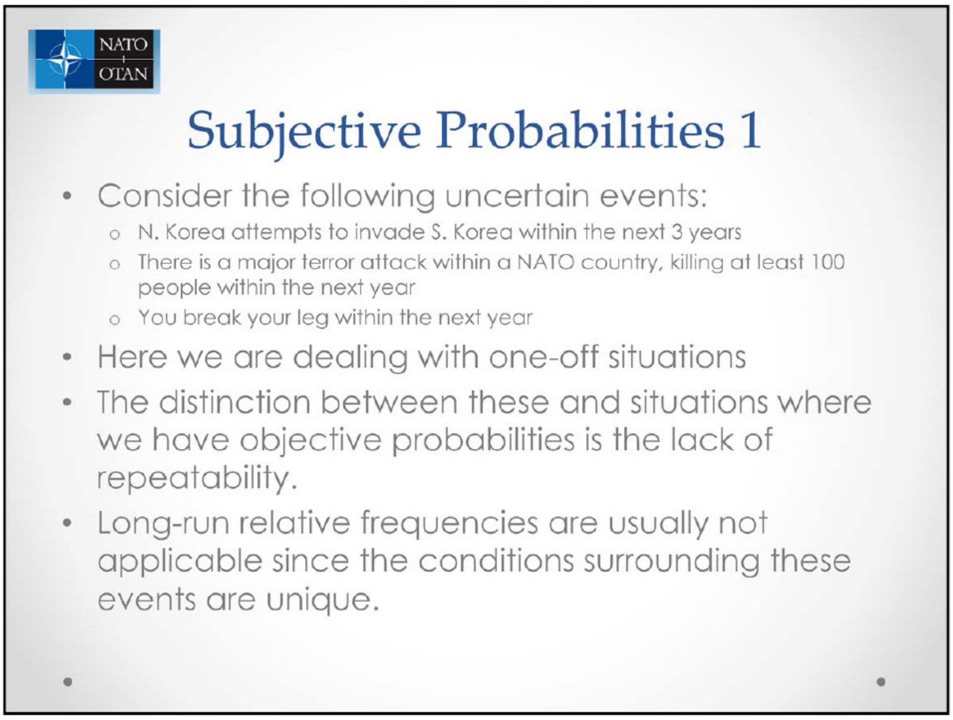


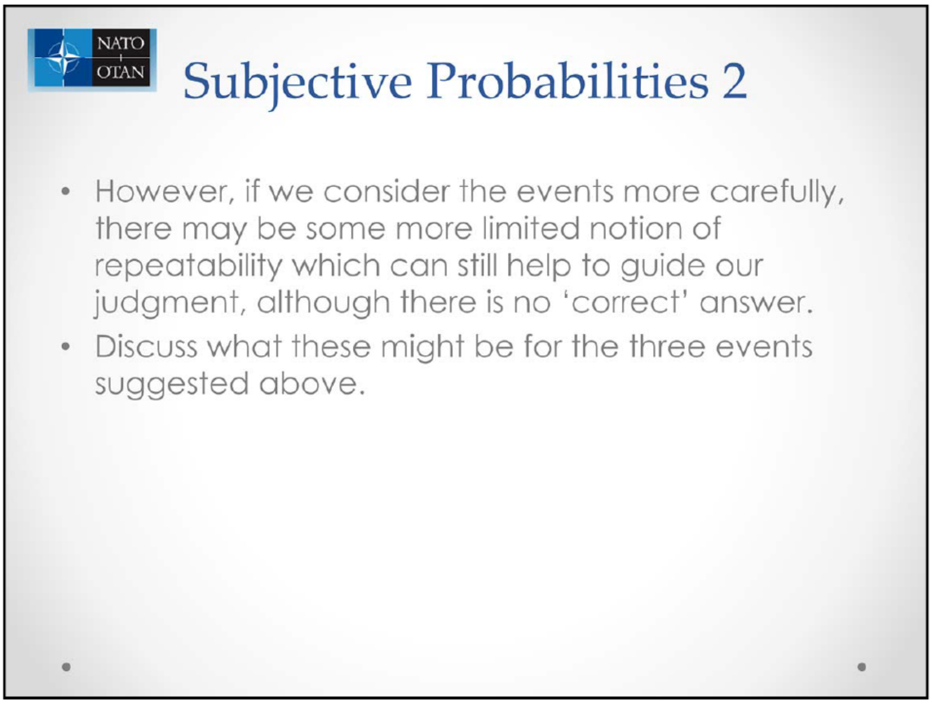
Decision Trees

- In a decision tree, however, final payoff values are displayed on the leaves at the right hand side of the tree, not probabilities.
- Each possible path has an associated payoff reflecting the value of that outcome.
- These are payoff values, not probabilities.
- In some cases, the outcomes will be costs which we wish to minimize rather than benefits which we wish to maximize.
- Both objective and subjective probabilities can be combined within the same tree.

Objective Probabilities

- When considering uncertain events such as tossing coins, drawing cards, etc, we employ *objective* probabilities which most people can agree on.
- Since the long-run relative frequency of each outcome provides an intuitive definition of probability in such cases, there is little room for ambiguity or disagreement.


NATO
OTAN
Subjective Probabilities 1
• Consider the following uncertain events:
o N. Korea attempts to invade S. Korea within the next 3 years
o There is a major terror attack within a NATO country, killing at least 100 people within the next year
o You break your leg within the next year
• Here we are dealing with one-off situations
• The distinction between these and situations where we have objective probabilities is the lack of repeatability.
• Long-run relative frequencies are usually not applicable since the conditions surrounding these events are unique.



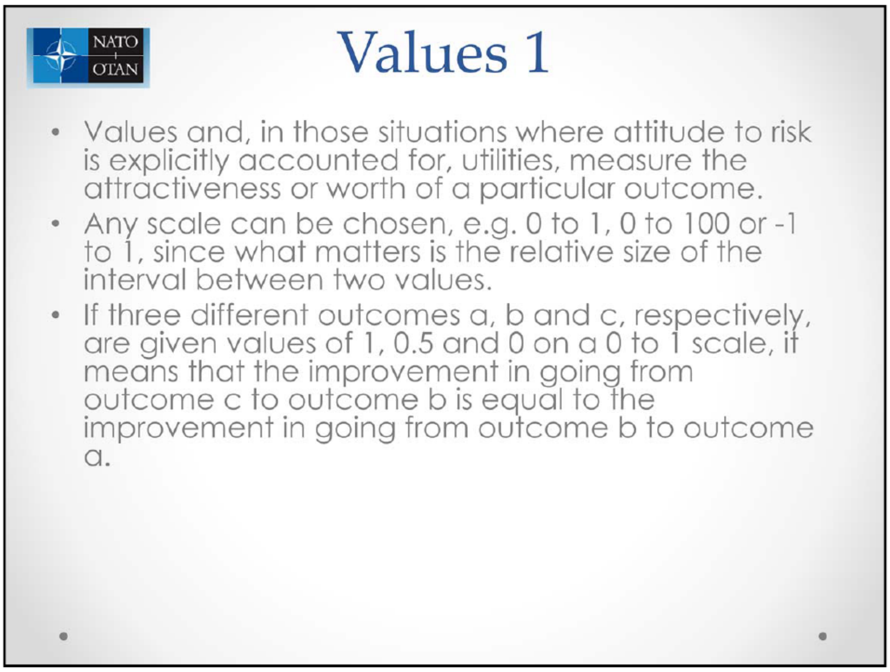
The notion is to identify some appropriate underlying baseline frequency for broadly similar events, where possible.

E.g. for the first one, we could look at the frequency of invasion between two neighbouring hostile countries in the last 50 years.

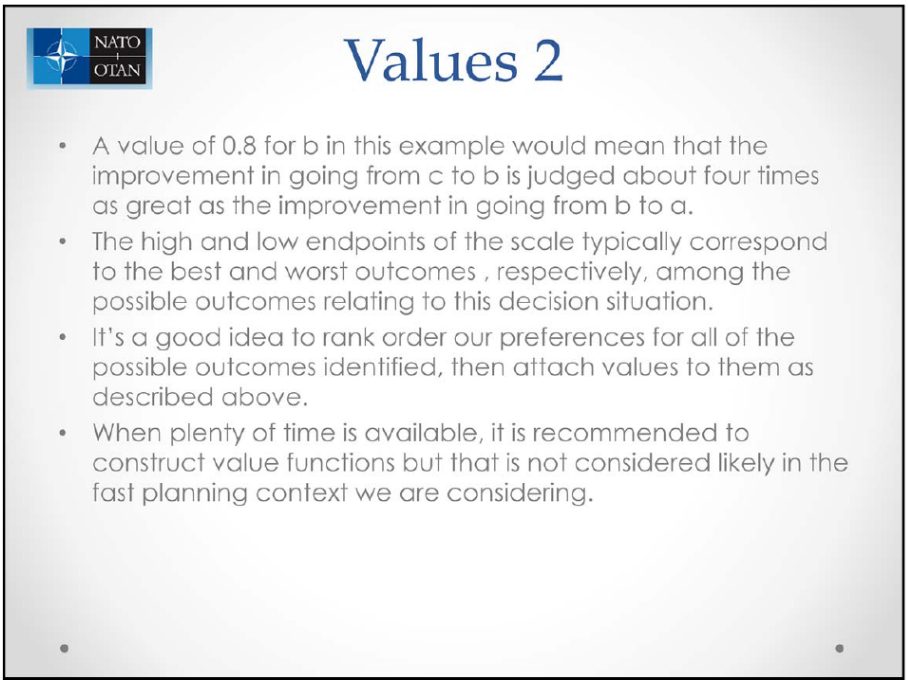
For the second, we could also look for more recent historical examples of major terrorist attacks on NATO soil to estimate a baseline frequency.

For the third, we could possibly obtain figures from a medical or insurance database and then compare our situation to the average, e.g. do we regularly take part in dangerous sports.

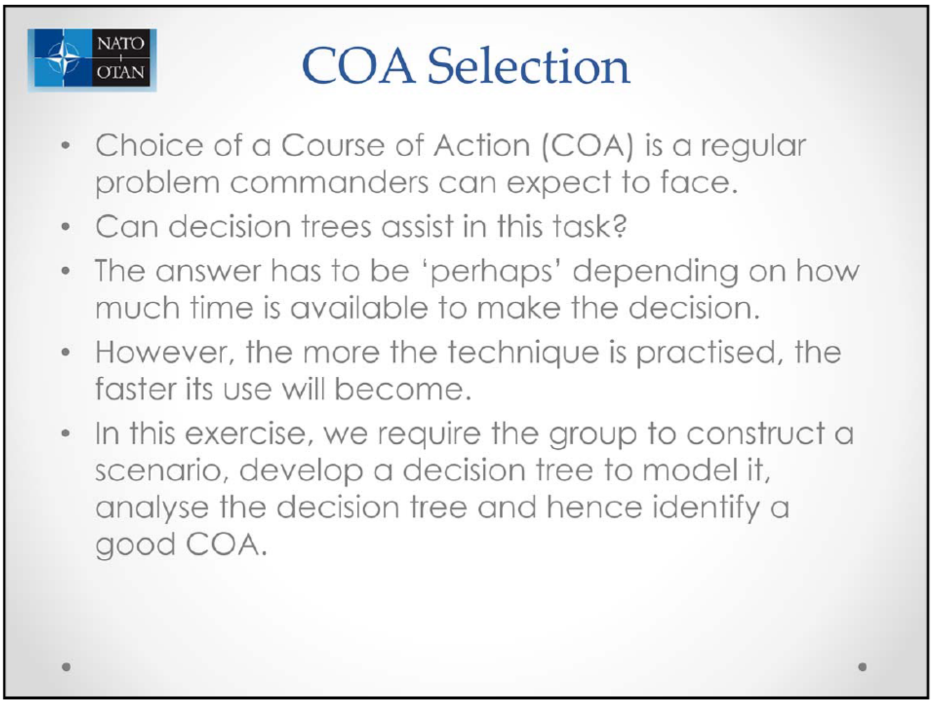
However, in each case, the unique circumstances need to be accounted for in the final subjective judgment. This means adjusting any such baseline figure by an appropriately judged amount to reflect the specific circumstances. Inevitably, personal experience, knowledge and beliefs will all play a part in this process. Consequently, different people will arrive at different subjective probabilities which is perfectly reasonable and to be expected.



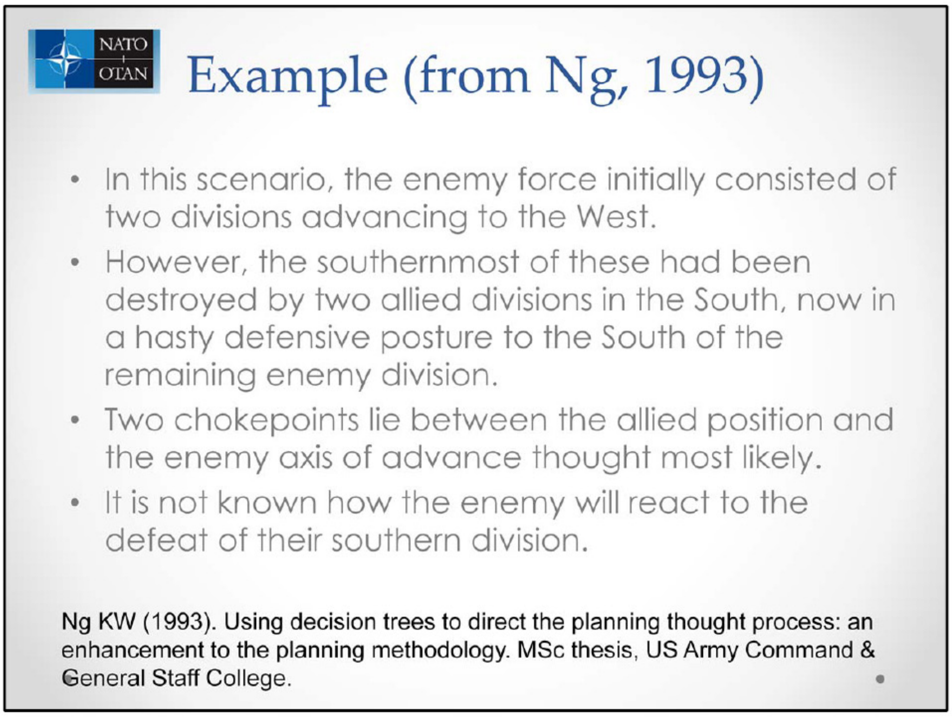
May need to emphasise that having an outcome with a utility of 1 does not mean it is twice as good as an outcome with a utility of 0.5. The scale is relative, not absolute. Even a utility of 0 might be OK, it is simply a baseline.



Here we are discussing values as though they are one-dimensional, e.g. monetary cost, but in many cases outcomes will be multi-dimensional. Either a vector of values can be presented for each outcome or, as in multi-criteria decision analysis, we can try to weight the importance of the different dimensions and collapse the vectors to aggregate values.



If the group are reluctant or require an example, an excellent case is provided by Ng (1993) which can be found on the Internet. But the greatest value will be provided by the group taking time to generate their own problem scenario.



Identify Both Sides' COAs

- E.g. in Ng(1993), the allied COAs are:
  - Remain in hasty defence
  - Advance into chokepoints
- Identify the allied and enemy COAs for the scenario created by the group at a similar level of detail to the above. You will need to consider who is going to act first in the chosen scenario.

Order of COAs

- In some scenarios, we might be waiting for the enemy to take some action before we respond.
- In such cases, our COA will be dependent on theirs and so will appear in the tree after theirs.
- In most scenarios, however, we might expect to take the initiative and choose our COA before the enemy has to respond to it.
- Then, the enemy choice of COA will depend on ours and so appear in the tree after ours.

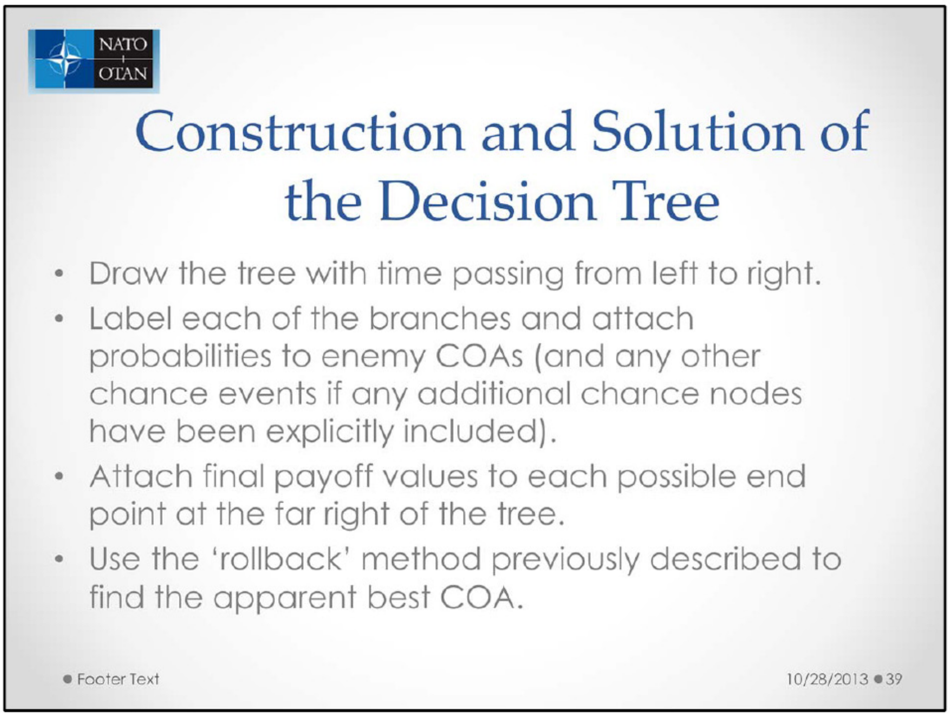
Describe the COAs

- For each COA on each side, write a brief description of it and what thinking might lead the side to take that COA.

Again, you could refer to the example from Ng(1993) if the group needs help with this.

Building a Decision Tree

- Our side's choice of COA is always represented by a decision node.
- The enemy choice of COA is represented as a chance node since it is not in our control.
- Probabilities of the enemy COAs are estimated, conditional on our chosen COA if it comes after our action, or vice versa if before.
- Payoff values of the various possible outcomes are also judged, typically although not necessarily, on a 0 to 100 scale. If people prefer to use a scale from some negative value to some positive value, where 0 is neutral, that is also intuitive.


NATO OTAN
Construction and Solution of the Decision Tree
• Draw the tree with time passing from left to right.
• Label each of the branches and attach probabilities to enemy COAs (and any other chance events if any additional chance nodes have been explicitly included).
• Attach final payoff values to each possible end point at the far right of the tree.
• Use the 'rollback' method previously described to find the apparent best COA.
Footer Text
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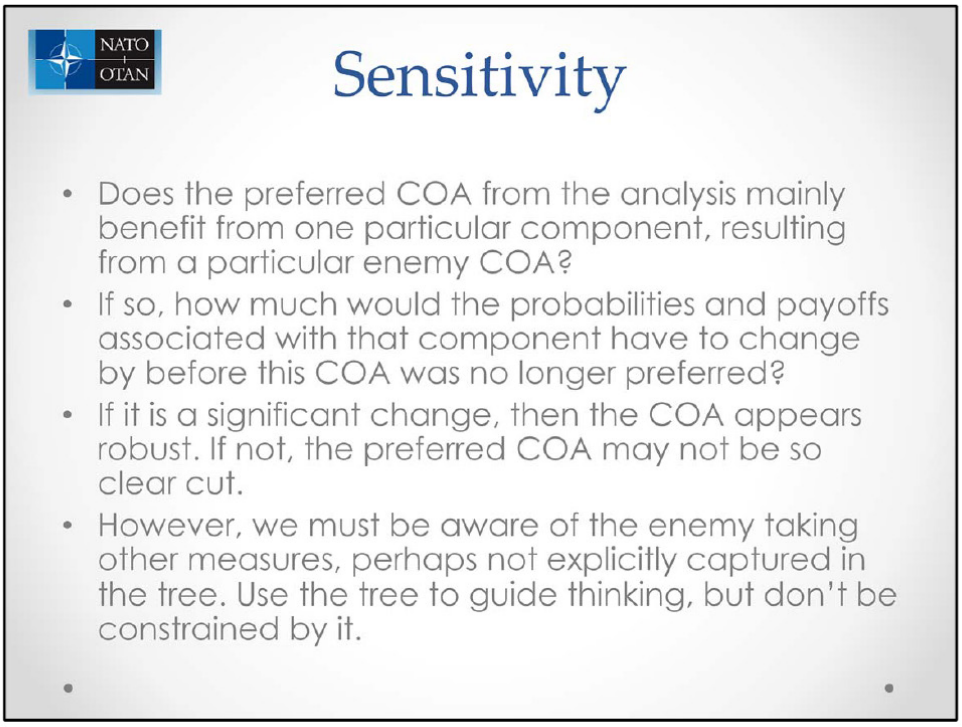
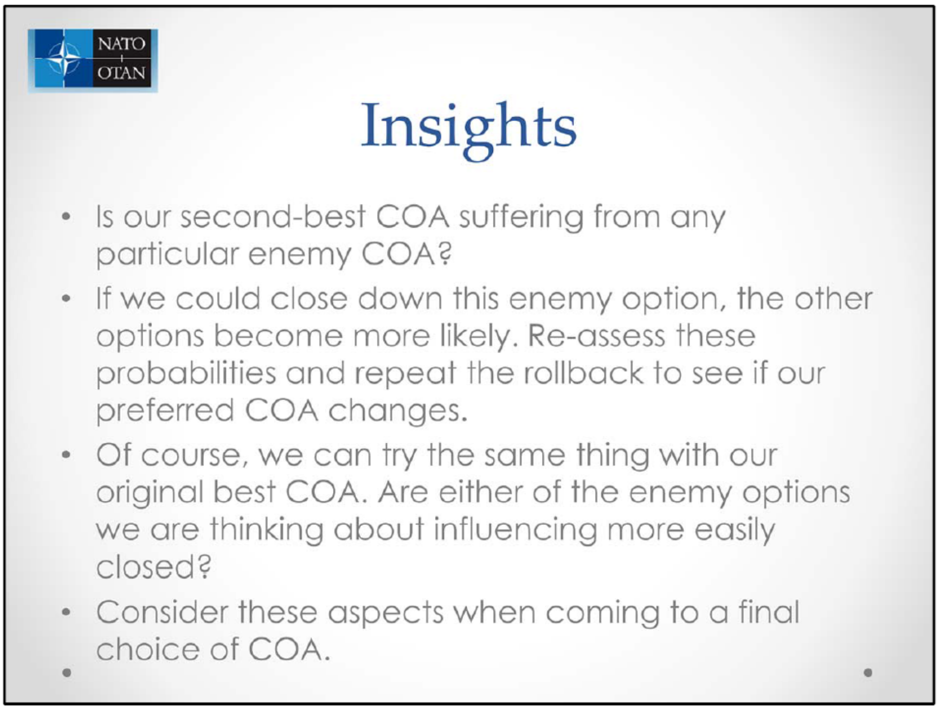
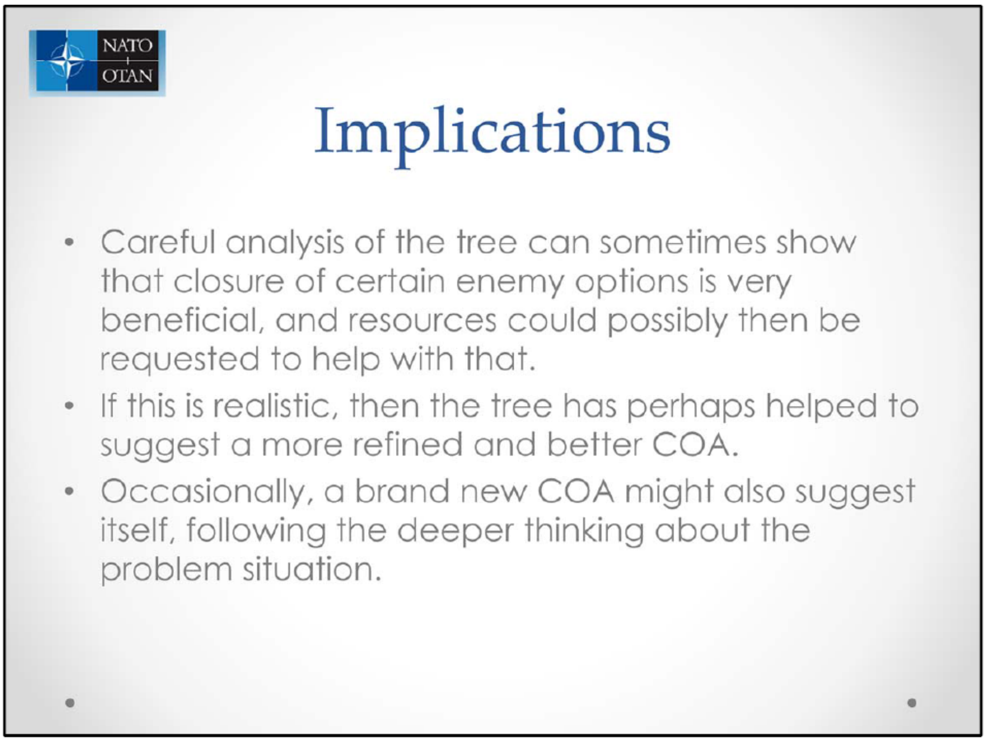
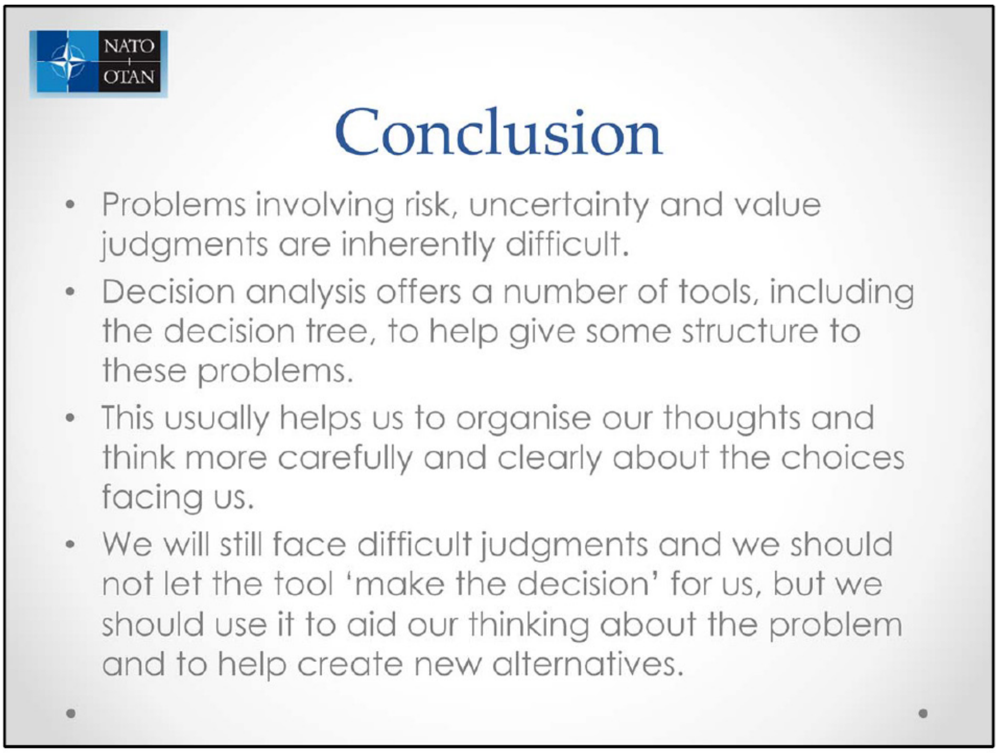

NATO OTAN
Sensitivity
• Does the preferred COA from the analysis mainly benefit from one particular component, resulting from a particular enemy COA?
• If so, how much would the probabilities and payoffs associated with that component have to change by before this COA was no longer preferred?
• If it is a significant change, then the COA appears robust. If not, the preferred COA may not be so clear cut.
• However, we must be aware of the enemy taking other measures, perhaps not explicitly captured in the tree. Use the tree to guide thinking, but don't be constrained by it.



For example, in Ng(1993), the inferior 'Secure chokepoints' COA suffered from the possibility of the enemy diverting North. If that chance could be reduced, it could become the better COA. Is one of the allied COAs which the group have developed suffering from a particular enemy COA? If so, can they do something to deter the enemy from taking that COA? Encourage the group to consider what actions they might be able to take which will influence the enemy COA in ways which improve our expected payoff.



If this doesn't follow from the group's tree, provide an example where it does, such as Ng(1993), so that they understand the point being made.



Recommended readings:
Making Hard Decisions, Clemen and Reilly
Decision Analysis for Management Judgment, Goodwin and Wright
The Failure of Risk Management, Hubbard
Using decision trees to direct the planning thought-process: an enhancement to the planning methodology, Maj KW Ng, Masters thesis, US Army Command and General Staff College, 1995. Accessed on 24 October 2013 at URL:
https://www.hsdl.org/?view&did=460707

A.7.3 Expeditionary Operations Morphological Analysis

INSTRUCTIONAL MODULE SUMMARY

Title	Analytical Techniques for Creating Useful and Agreeable Definitions
Faculty Name(s)	Han de Nijs, ACT, NATO
Length	20 – 30 minutes
Learning Objectives	Develop useful terminology to make a better decision.
Outcomes	As the result of this module, participants will be able to: Appreciate the OA tools available to define problems. Understand the use of techniques to develop the terminology and identify areas of consensus.
Content Outline	NATO Expeditionary Ops using the conventional approach. NATO Expeditionary Ops using morphological analysis. Classic and extended morphological analysis. Rule sets and analysis of results. Application and OA contribution. Case Study: NATO response to Pakistan earthquake.
Materials	List Required Pre-Readings: None.
Methods	80% Lecture 20% Class discussion. _____ % Break Outs.
Exercise(s)	None.
Break Outs	___ Yes X No. __#___ participants in each break out group.
Discussion Questions	In your experience, where has hierarchical clustering of costs and use of decision trees been used to estimate costs?

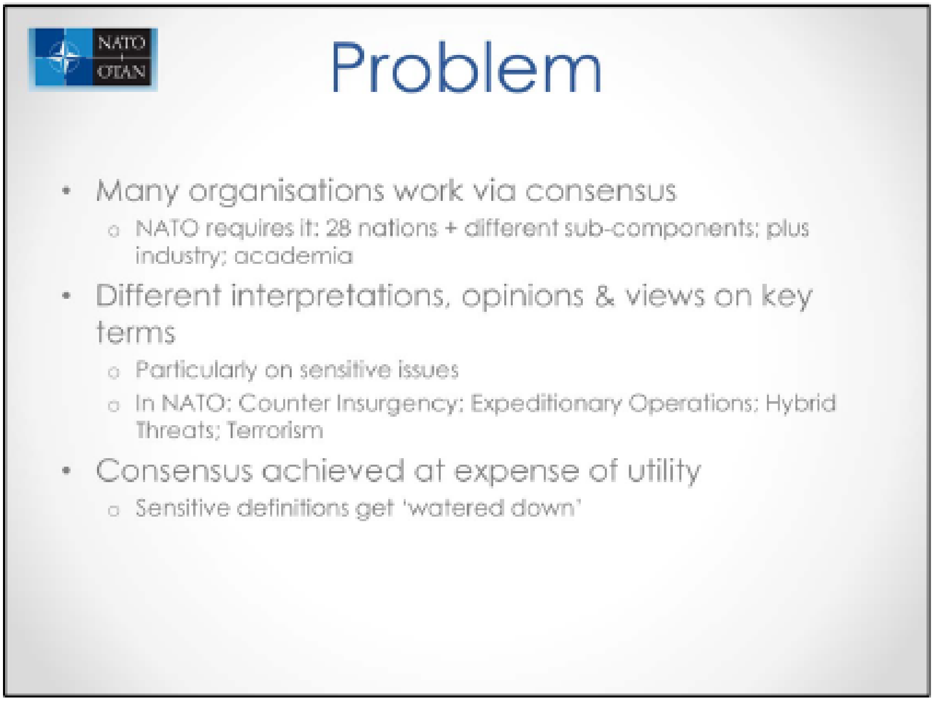
Analytical Techniques for Creating Useful and Agreeable Definitions

Draft for SAS-098, RTG-043 7/15/2013 1

Overview

- **Situation**: Problem formulation
- **Decision**: Determine an agreeable definition
- **Objective**: Develop useful terminology to make a better decision
- **Analysis Contribution**: Use of techniques to develop the terminology and identify areas of consensus

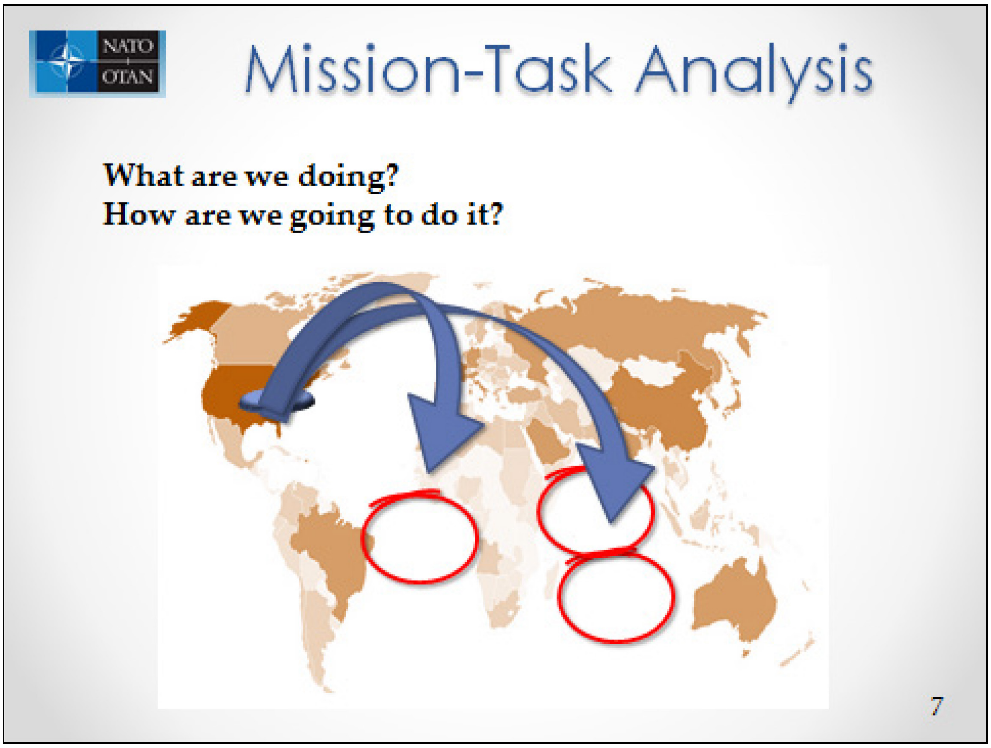
3

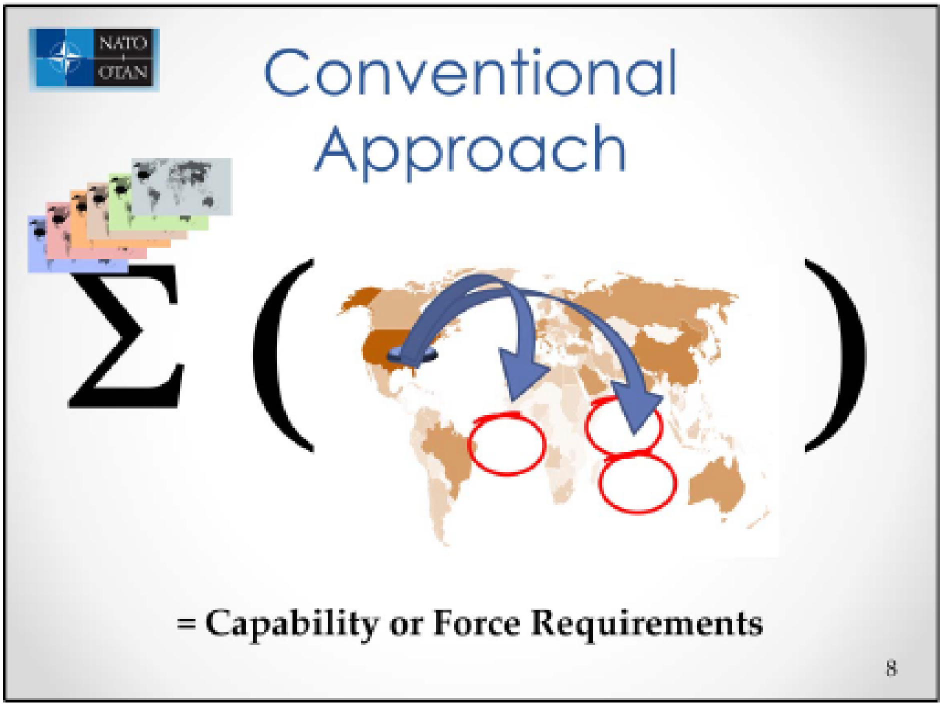


This is a problem, and I'm going to show a solution using the case study 'expeditionary operations'.

NATO – like many organisation – works on a principal of consensus – actually within NATO consensus is much more formalised. Each NATO can effectively veto activity


NATO OTAN
Create future scenarios
Where are we operating?
When are we doing it?
6


NATO OTAN
Mission-Task Analysis
What are we doing?
How are we going to do it?
7


NATO
OTAN
Conventional
Approach
Σ ( )
= Capability or Force Requirements
8

Speaking notes
-Current NATO definition – an example of how agreement is at the expense of usefulness
-Traditional capability requirements analysis - create scenarios – mission task analysis
- This definition covers all scenarios

This is the current NATO definition of Expeditionary Operations. In conventional Capability Requirements analysis, the normal process would be to take a concept or environment, develop it into scenarios, and from those scenarios identify the capabilities required through a mission / task analysis.

The problem is that the definition is (for capability analysis purposes) poor. The definition is typical of NATO definitions, it is what 28 nations can agree on; it is vague and it would difficult to use it to develop a robust set of scenarios.

Speaking notes
-Current NATO definition – an example of how agreement is at the expense of usefulness
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Conventional Approach	NATO Definition
Where are we operating?	*"…a distant operational area…"*
When are we doing it?	[*In the future…*]
What are we doing?	*"…accomplish a specific objective."*
How are we going to do it?	*"…project military power over extended lines of communications …"*

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Qu	NATO Definition	Specific ?
Where?	*"…a distant operational area…"*	☹
When?	[*In the future…*]	☹
What?	*"…accomplish a specific objective."*	☹
How?	*"…project military power over extended lines of communications …"*	☹

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Speaking notes
-Definition has been developed
-Lacks clarity
-An operation may be all missions across the globe at all scales, but not at the same time.

The EO ICT has developed a 'conceptual vision and framework'. This document does include some useful indicators, "...long lines of communication..." and "...austere environments...", however it also includes the following.

Whole mission-type spectrum may include: Urban operations, counter-WMD, Information Operations, extended Force Protection etc

It may be true that EO covers all missions, across the globe, and at all scales, but we believe that any individual scenario is unlikely to combined the most stressing of all these things at the same time.

Qu	NATO Definition	EO Vision	Specific?
Where?	*"…a distant operational area…"*	**Far**; **austere**; **global**	☹
When?	[*In the future…*]	…	☹
What?	*"…accomplish a specific objective."*	**whole** mission-type spectrum	☹
How?	*"…project military power over extended lines of communications …"*	**rapidly**; **all** scales;	☹

Problem

- Scope of expeditionary operations very broad
- With current information:
  - **Difficult** to determine what isn't a NATO expeditionary operation
  - **Impossible** to determine capability requirements

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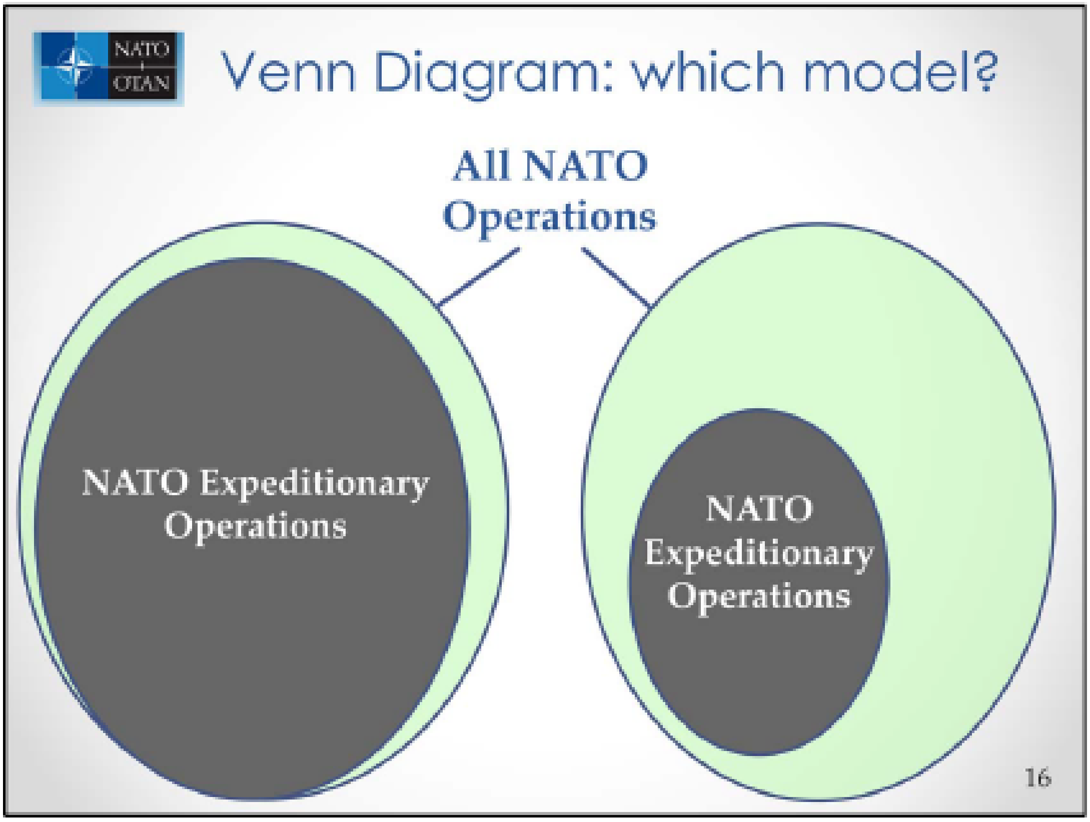
NATO OTAN
Venn Diagram: which model?
All NATO Operations
NATO Expeditionary Operations
NATO Expeditionary Operations
16

Speaking notes
-focus on the characteristics that describe EO, but the first step is to identify all characteristics
- Morphological analysis + Classification trees – novel - no example of this before
-Other techniques were considered

This is the outline method.

We aspired to determine a sub-set of the NATO endeavours that would be considered to be Expeditionary Operations. Clearly, a sensible first step was to identify the full set of NATO endeavour.

Method selection:
Why MA and why classification trees – we did look at other techniques e.g. Historical Analysis and traditional scenario development

Combining the two methods is considered novel, we have not found any other examples of the employment of these two techniques in such a manner.

Structuring a Problem with Morphological Analysis

- Develop categories to describe the problem
  - "Dimensions"
- Identify different states in each category
  - "Scalars"
- With experts discuss validity of permutations
  - Morphological table

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Dimensions & Scales for All Operations

Dimensions	Scales
Speed of Response	Days; weeks; months
Duration	Enduring; non-enduring
Distance	Within NATO; out of NATO
Scale	Sub-state; country; regional; global
Mission Type	Deliberate; Intervention; Focused Intervention; Power Project; Evacuation; Humanitarian Operation; Peacekeeping; Peace Enforcement
Human environment	Homogenous; heterogeneous integrated; heterogeneous segregated
Physical environment	Rural; urban; littoral; ocean; space; Arctic ;Antarctic
Infrastructure	Bare; austere; well found
Threat	Permissive; non-permissive

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Held a two day workshop with representatives (nations, operators, problem owners, analysts) and developed and agreed a set of dimensions and scalars that could be used to describe any NATO operation.

Morphological Table

Speed of Response	Duration	Distance	Scale	Mission Types	Human Environment	Physical Environment	Infra-structure	Threat
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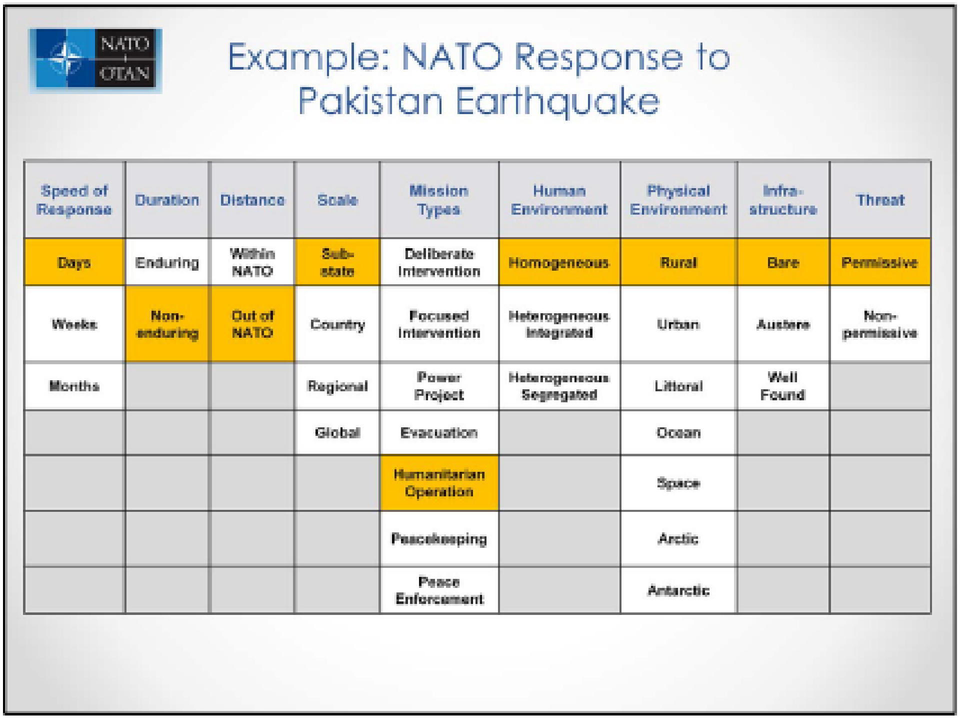
Speaking notes
-The SAS team came up with this Morphological Table
-It has nine dimensions (called parameters in MA) , and a number of scalars (parameter values) for each
- assumption that any military operation can be described

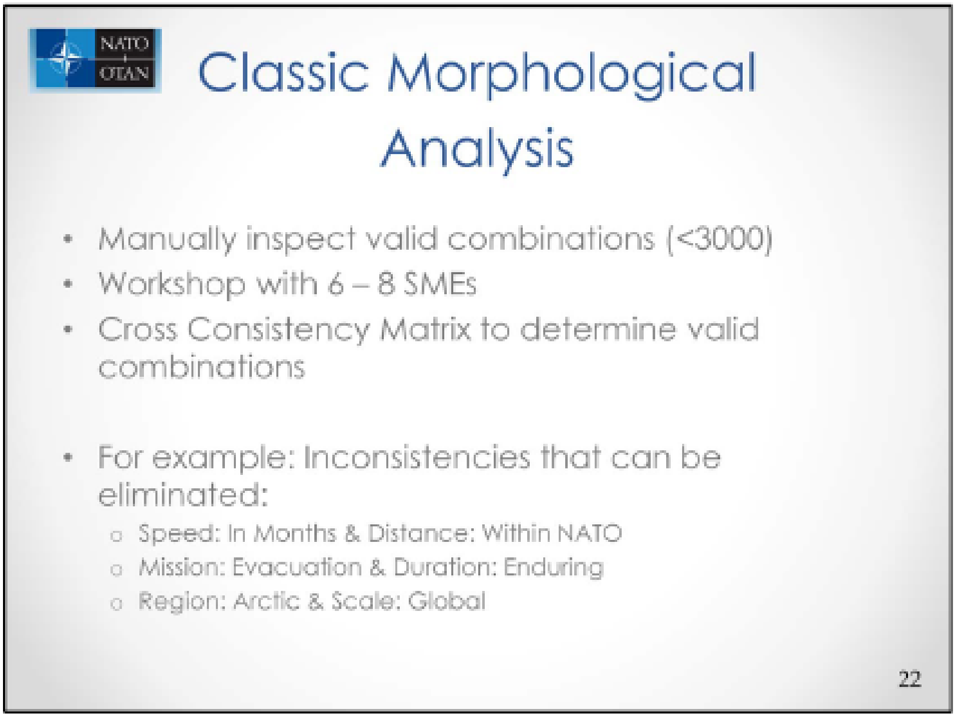
Study Team met (spring 2008) and developed 9 dimensions (parameter in MA speak) and scalars for each dimension (parameter values).

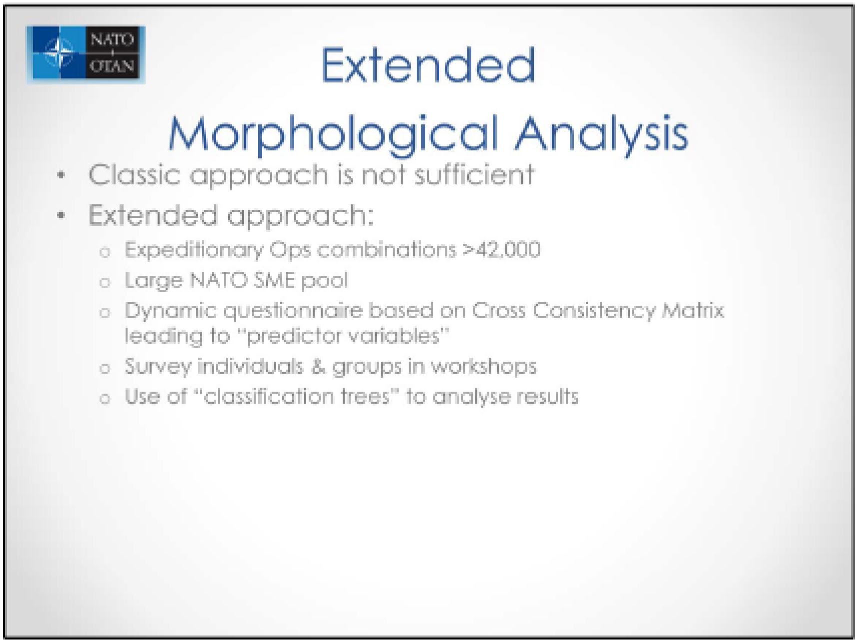
It was our assumption that any military operation should be able to be described using a single combination of characteristics. (NB At the spring meeting we took nine historical operations and attempted to describe them using the dimensions and scalars).



Speaking notes

- NATO response to Pakistan Earthquake





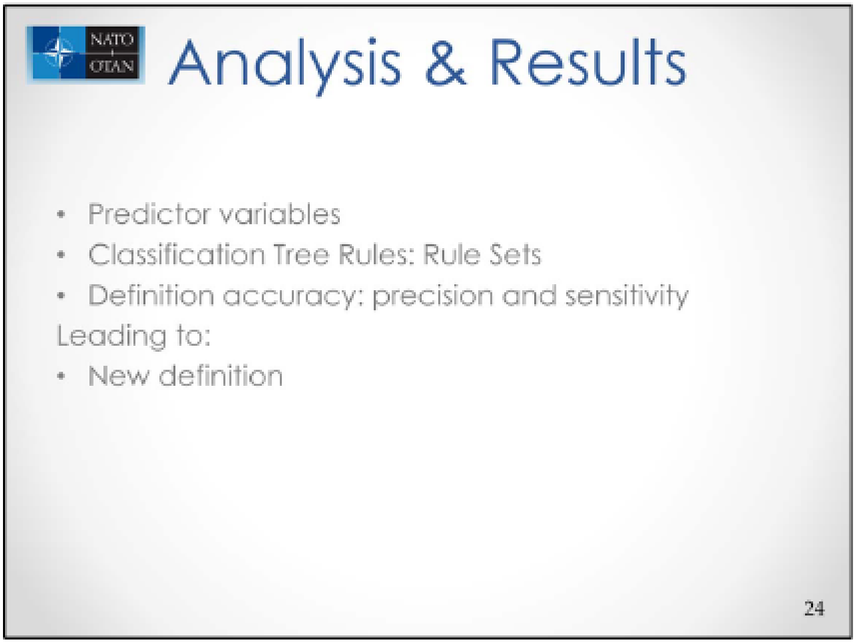
Speaking notes
-Classic approach inadequate
-Table too large, many stakeholders
-Questionnaire – can be emailed, or used as a facilitation tool
-Sample of data from questionnaire is limited

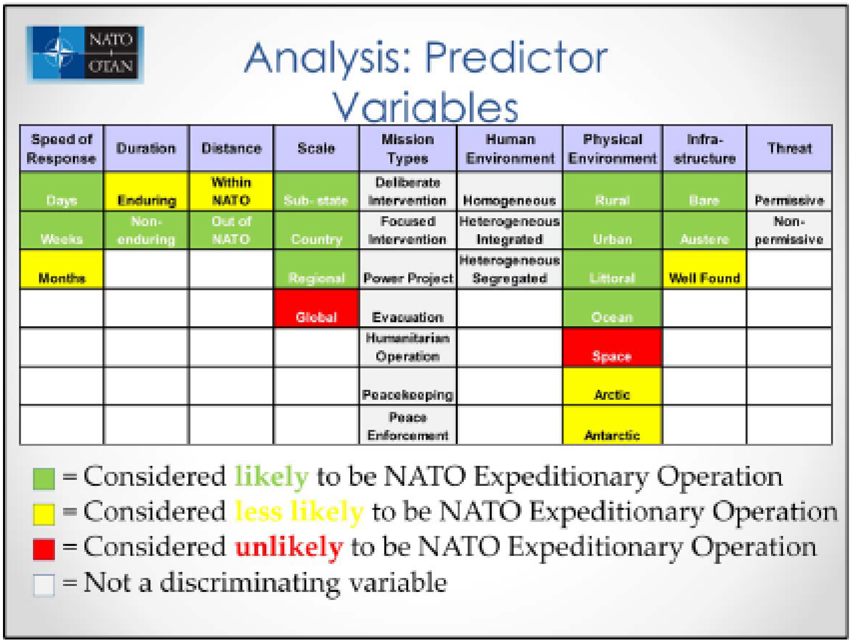
Classic Approach = 5 or 6 dimensions, with up to four scales, a group of 6 experts works through all of the combinations (~4000) using a Cross Consistency Matrix.

With a bigger problem (42000 combinations) and larger number of SMEs to poll, we can't do the classic approach, and we extended it to create a data set that could be analysed.

Dynamic Questionnaire (questionnaire changes as respondent answers) reduced questions from 500 to something that can be completed within 20-30 mins. Questionnaire was used both individually and as a facilitation tool as part of workshops with multiple SMEs.

Issued the questionnaire…
Number of responses?
We modified our approach – facilitated sessions…





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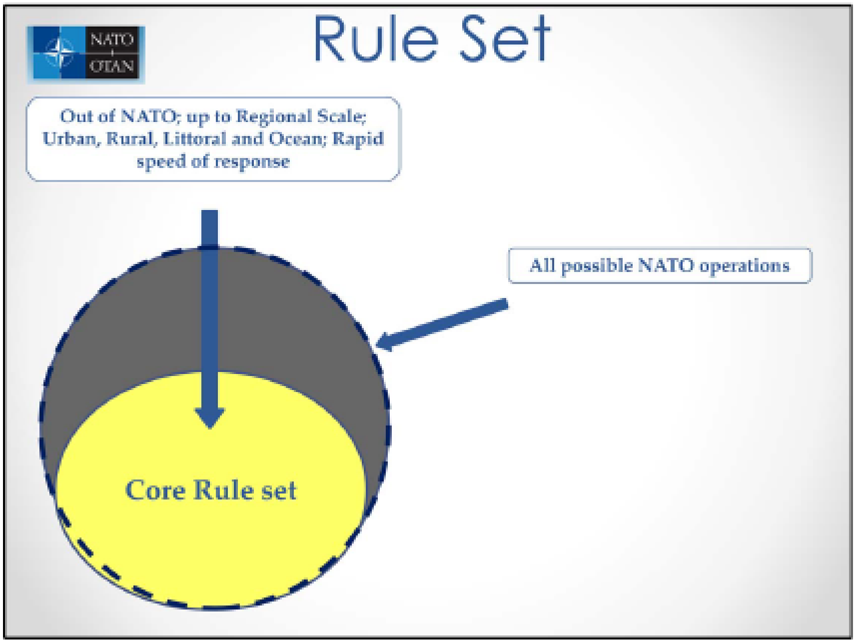
Speaking notes
-This is a simple table showing the results
-Allows quick glance to see strong influences (Global, Space, any mission type, threat etc)
-Disadvantage – does not show combinations

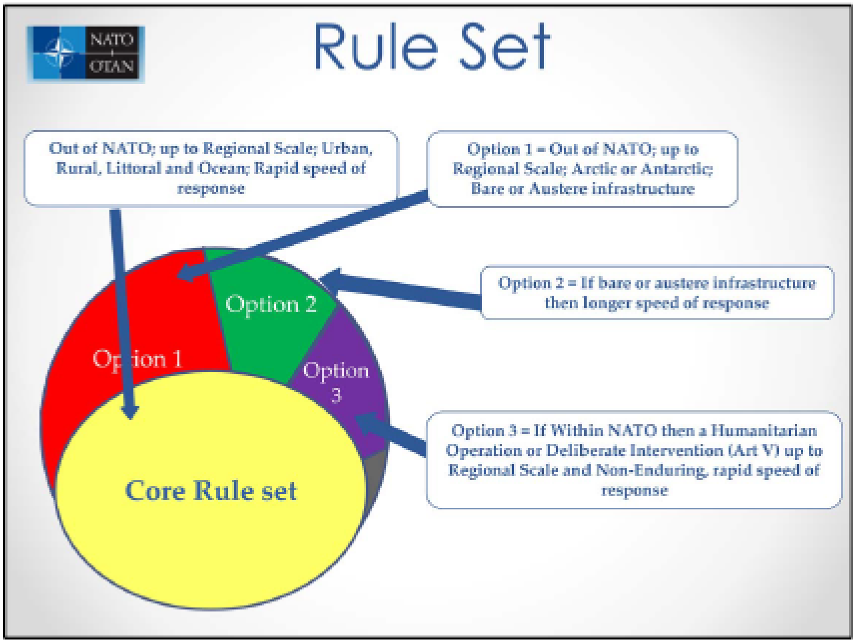
It gives the analyst a quick look at the data, to see strong influences.

It is also simple to understand.

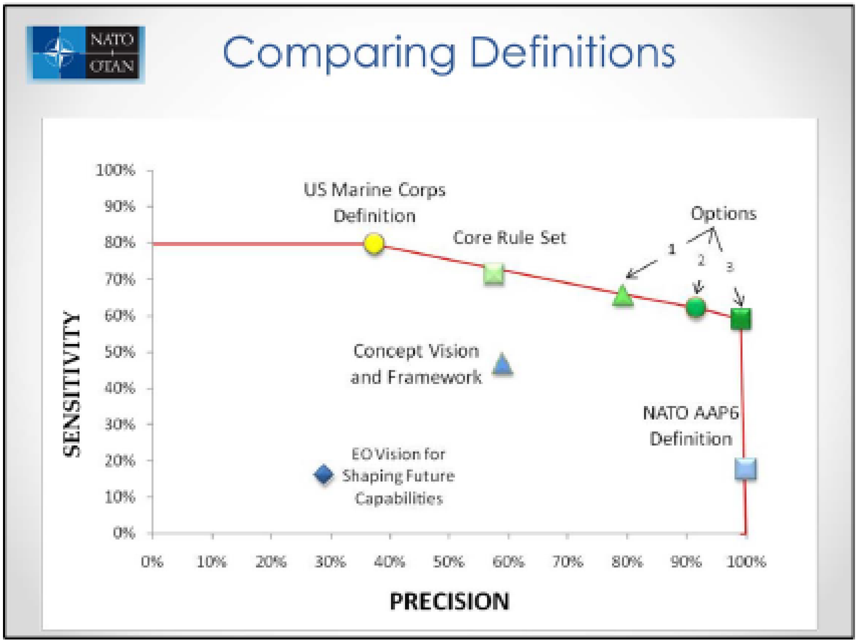
It does have disadvantages though, the main one being it doesn't show combinations



Speaking notes
-By going through a similar process, alternative definitions can be derived
-Each option represents a different branch of the tree

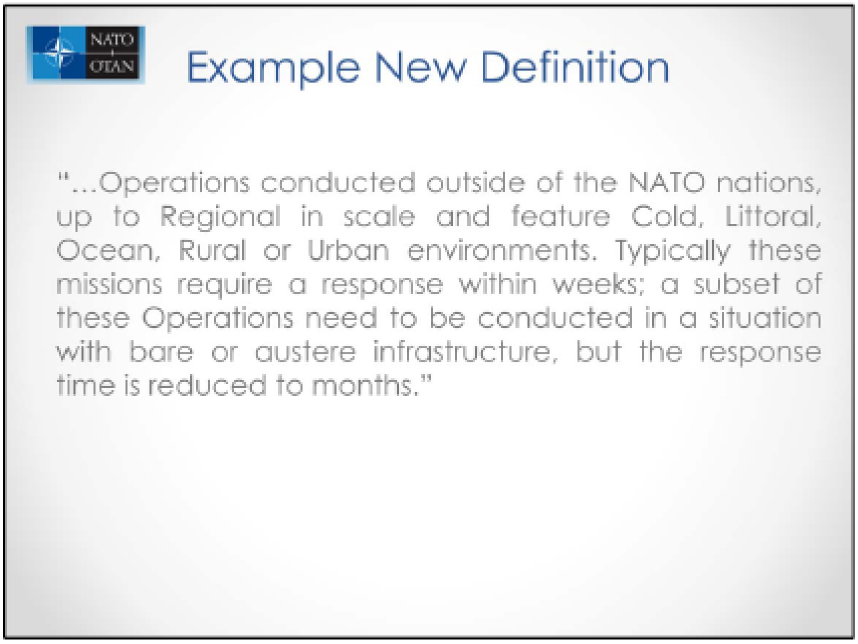


Speaking notes
- Opt 3 is OUT of NATO
-Core set + Opt 1 + Opt 2 + Opt 3= 99%
-Core set + Opt1 & 2 can be combined.



Speaking notes

- **Core rule set – better than EO vision – less sensitive (specific) but more precise (coverage) than USMC.**
- **Options – improve precision coverage at the expense of sensitivity.**



Proposed definition is longer, but has much more detail, useful for capability requirements analysis

Qu	New Definition	Specific?
Where?	*"…outside of NATO Nations up to regional in scale…"*	☺
When?	[*In the future…*]	☹
What?	*"…in a Cold, Littoral, Ocean, Rural or Urban environment."*	☺
How?	*"…[quickly] typically a response within weeks; or months with bare or austere infrastructure…"*	☺

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OA Contribution

- Create more useful terminology
- Gain consensus by:
  - Highlighting areas of agreement
  - Providing options where there is disagreement
- Comparison of different definitions

7/15/2013 31

How did we do it?

- Executive Session ends here
- What follows is further detail on the methodology
- Only of interest to the Analyst and Experts

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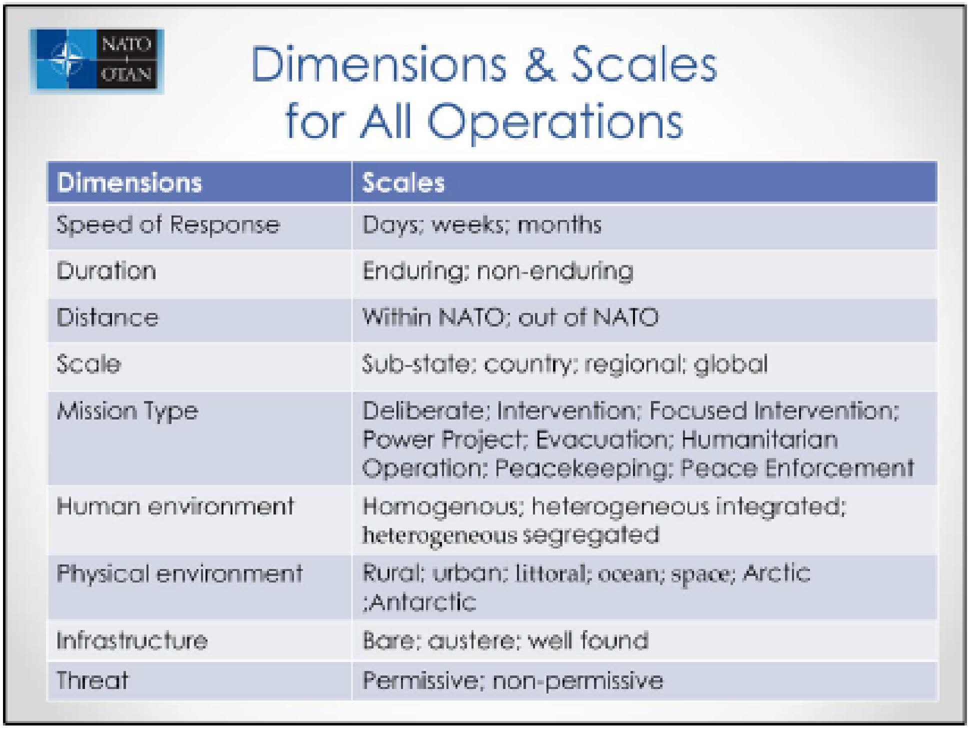
Structuring a Problem with Morphological Analysis

- Develop categories to describe the problem
  - "Dimensions"
- Identify different states in each category
  - "Scalars"
- With experts discuss validity of permutations
  - Morphological table

33



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Example: NATO Response to Pakistan Earthquake

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Speaking notes
- NATO response to Pakistan Earthquake

Cross Consistency

		Speed of Response			Duration		Distance		Scale			
		Days	Weeks	Months	Enduring	Non-enduring	Within NATO	Out of NATO	Sub-state	Country	Regional	Global
Duration	Enduring	M	Y	Y								
	Non-enduring	Y	Y	Y								
Distance	Within NATO	Y	M	N	M	Y						
	Out of NATO	Y	Y	Y	Y	Y						
Scale	Sub-state	Y	Y	Y	Y	Y	N	Y				
	Country	Y	Y	Y	Y	Y	M	Y				
	Regional	Y	Y	Y	Y	Y	Y	Y				
	Global	N	N	N	N	N	N	N				
Mission Types	Deliberate Intervention	Y	Y	M	N	Y	Y	Y	Y	Y	Y	N
	Focused Intervention	Y	Y	N	N	Y	N	Y	Y	Y	Y	N
	Power Project	Y	Y	Y	N	Y	N	Y	Y	Y	Y	N
	Evacuation	Y	M	N	N	Y	N	Y	Y	Y	Y	N
	Humanitarian Operation	Y	M	N	N	Y	M	Y	Y	Y	Y	N
	Peacekeeping	Y	Y	Y	Y	N	N	Y	Y	Y	Y	N
	Peace Enforcement	Y	Y	N	Y	Y	N	Y	Y	Y	Y	N

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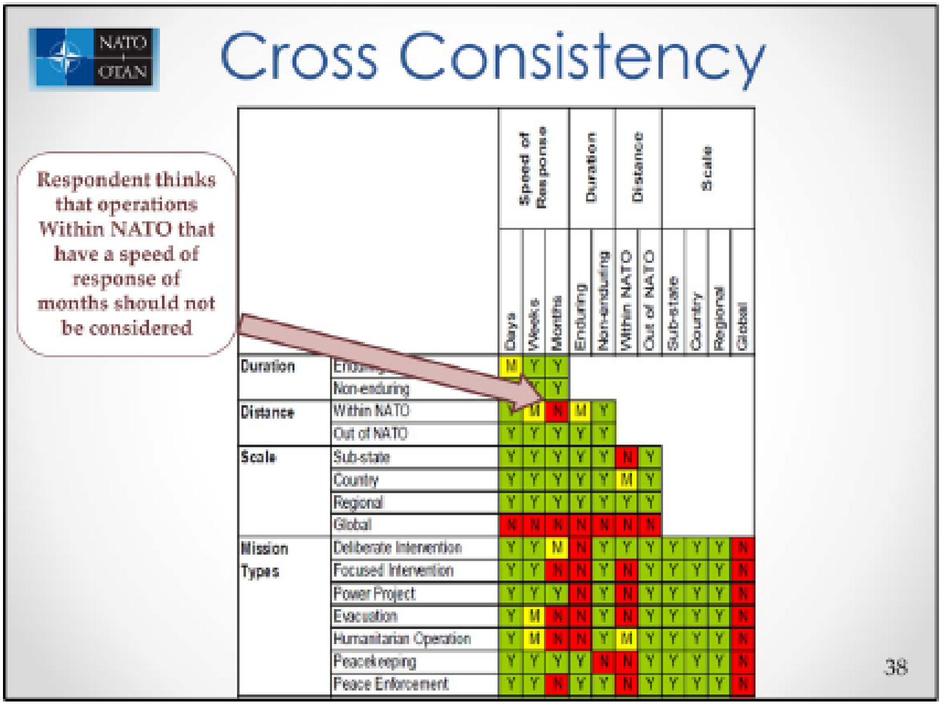

		Speed of Response			Duration		Distance		Scale			
		Days	Weeks	Months	Enduring	Non-enduring	Within NATO	Out of NATO	Sub-state	Country	Regional	Global
Duration	Enduring	M	Y	Y								
	Non-enduring	[illegible]	Y	Y								
Distance	Within NATO	Y	M	N	M	Y						
	Out of NATO	Y	Y	Y	Y	Y						
Scale	Sub-state	Y	Y	Y	Y	Y	N	Y				
	Country	Y	Y	Y	Y	Y	M	Y				
	Regional	Y	Y	Y	Y	Y	Y	Y				
	Global	N	N	N	N	N	N	N				
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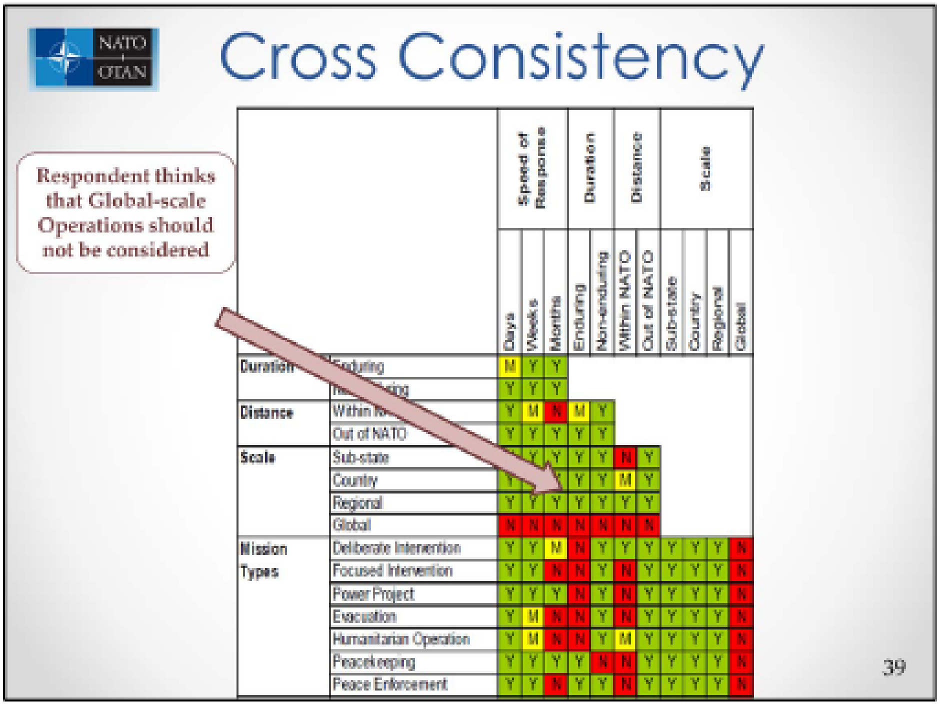

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	Country	Y	[illegible]	[illegible]	Y	Y	M	Y				
	Regional	Y	Y	Y	Y	Y	Y	Y				
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	Evacuation	Y	M	N	N	Y	N	Y	Y	Y	Y	N
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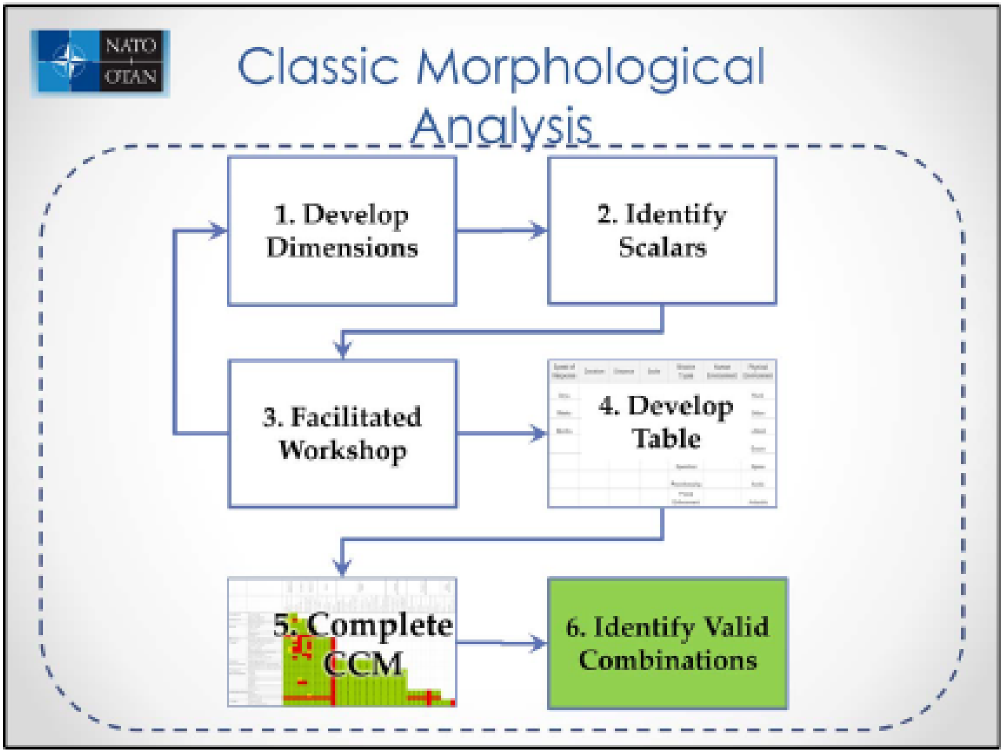
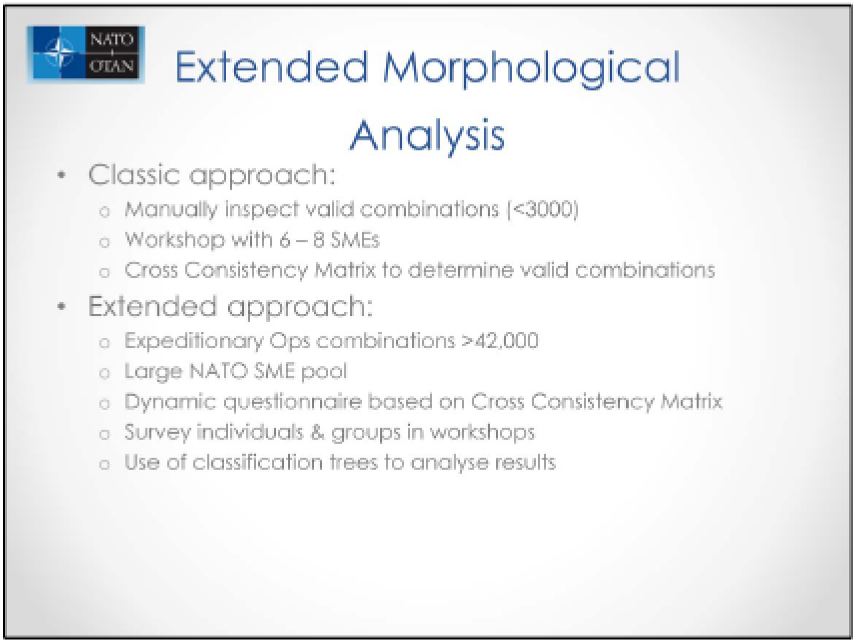


Speaking notes
-Classic methodology is to agree on the dimensions of the problem
- Through a series of facilitated workshops
- Discuss combinations and come up with a definition



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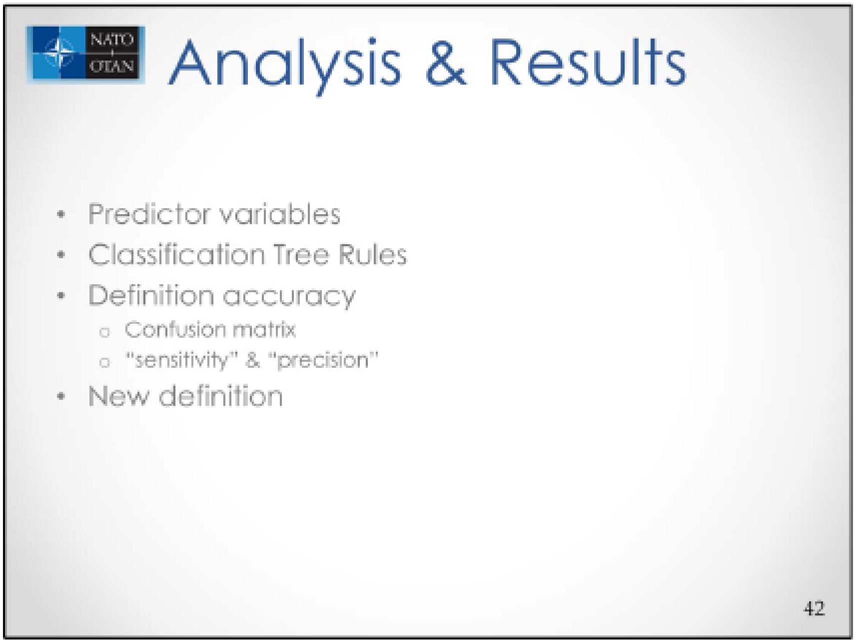

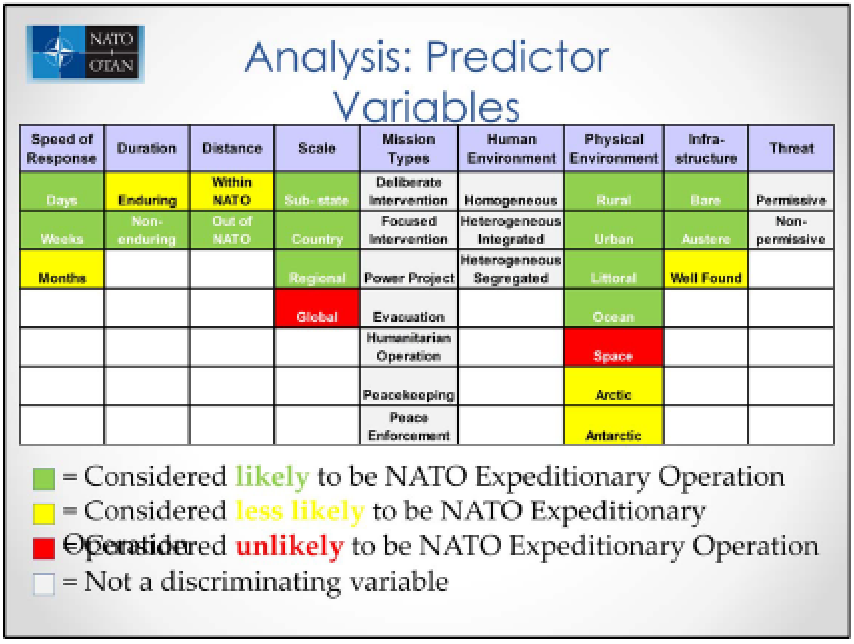

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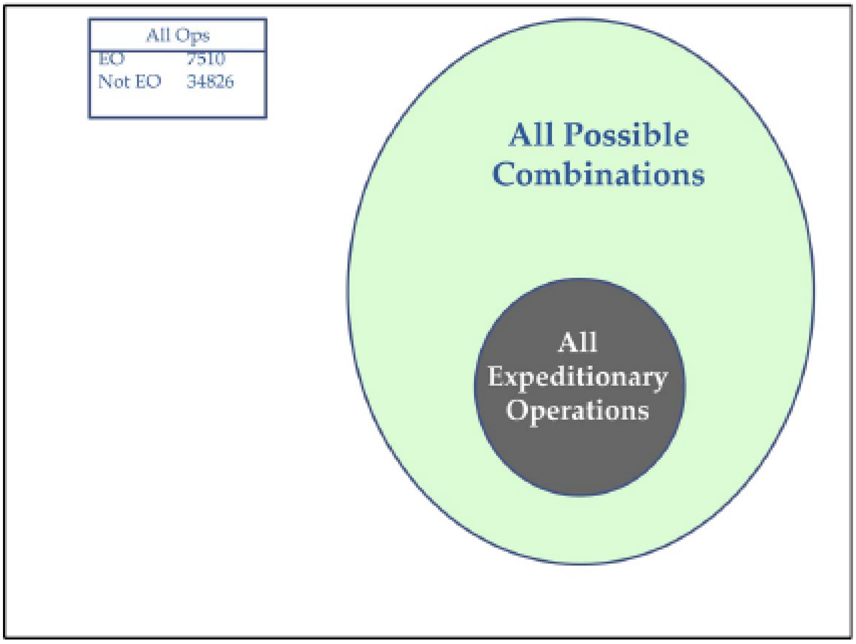
It is also simple to understand.

It does have disadvantages though, the main one being it doesn't show combinations



Speaking notes

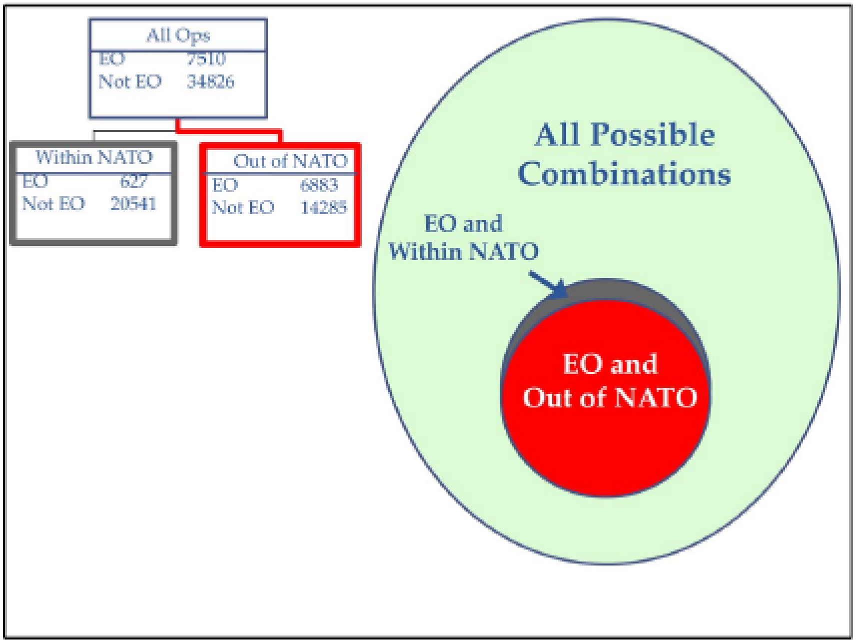
-Show how classification tree builds (on LEFT), Venn diagram is to Scale

-1st level - how many of total combinations are considered Expeditionary

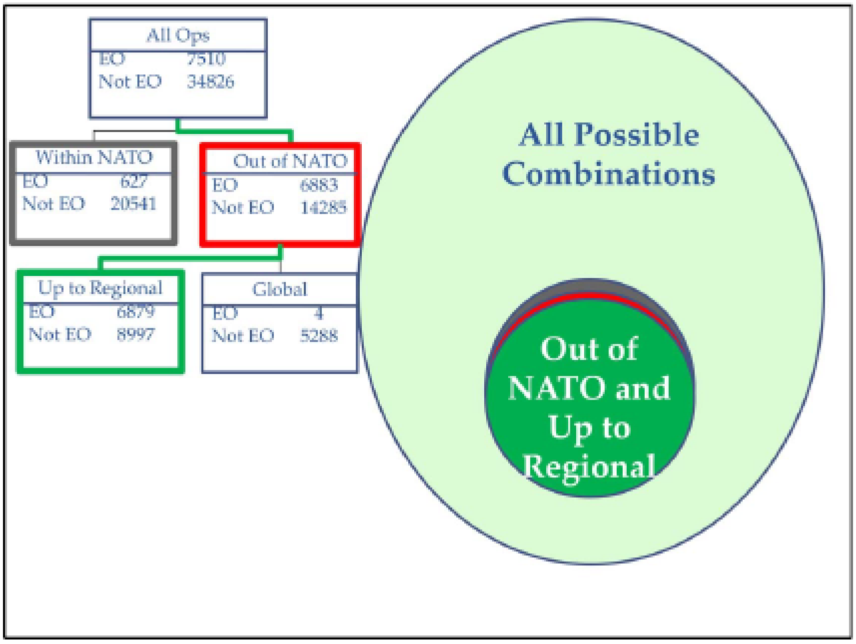
-Non-expeditionary may also mean Not-Valid

- *-Logical Contradictions* ***e.g. Within NATO and Antartic***
- *-Empirical Inconsistencies e.g. Peacekeeping at Global Scale*
- *-Normative Constraints e.g. Against NATO policy*

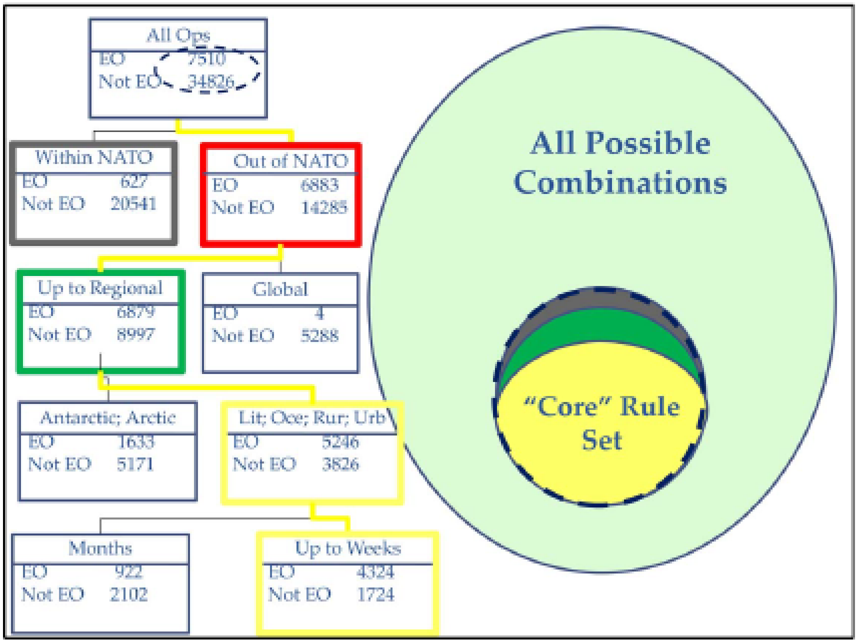
Non-expeditionary operations may be those that are not feasible (i.e. Antartic, Within NATO) or those that are valid operations but not considered expeditionary



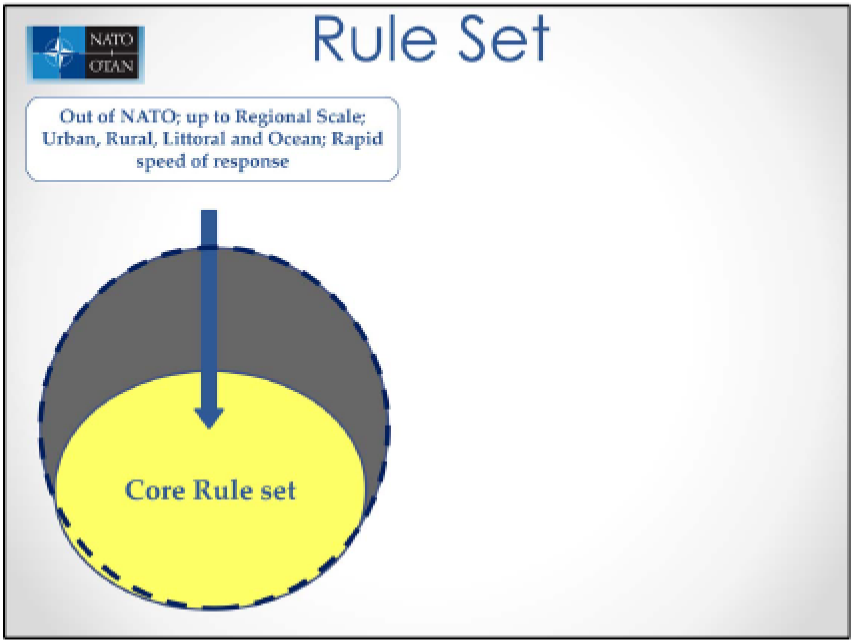
Speaking notes
-2nd Layer
-Distance is most important
-Covers 92% of ops



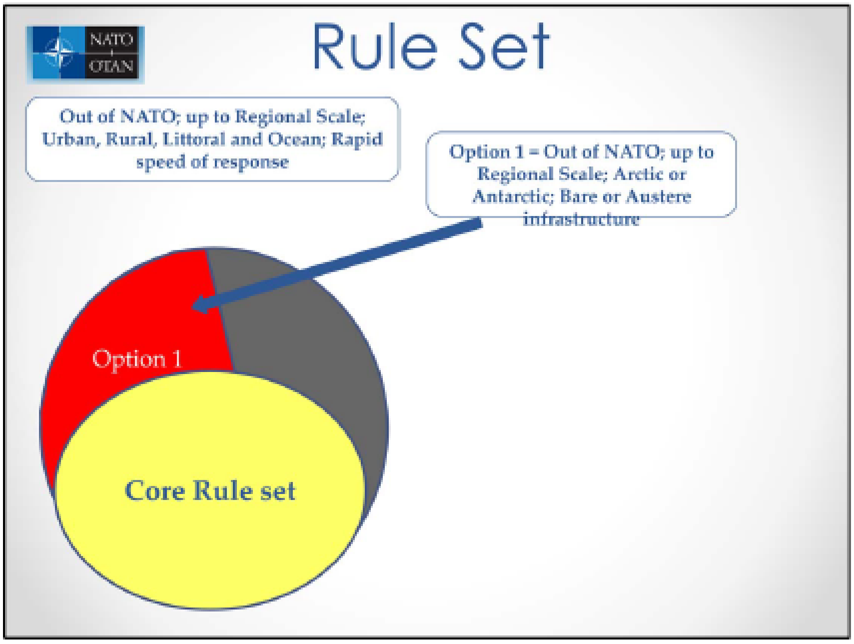
Speaking notes
-3rd Layer
-Scale is next important
-Only 4 operations at Global scale are considered valid



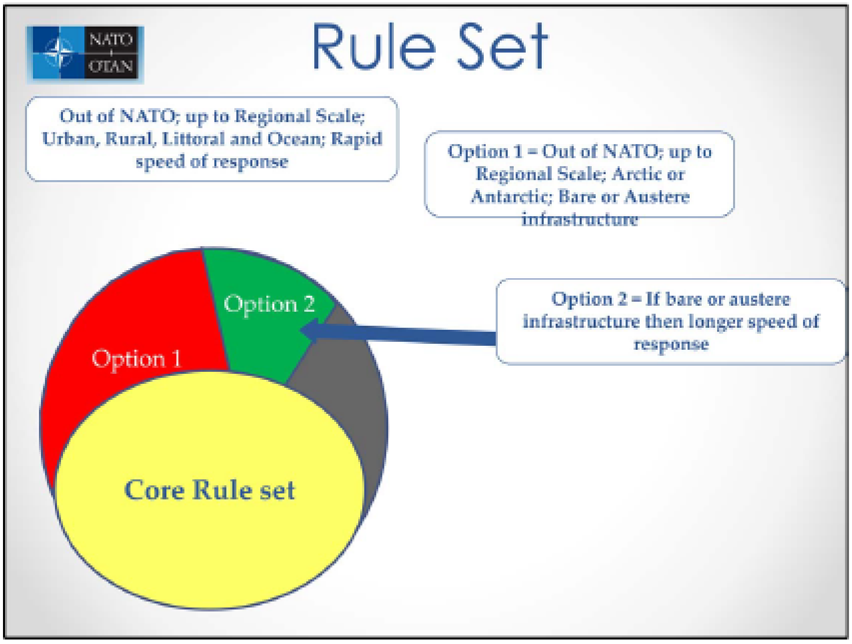
Speaking notes
-Build up to 'Core Rule Set'
-Is good but not good enough! It only covers around 58% of all EO
-Can use the same approach to fill in the remaining 42%



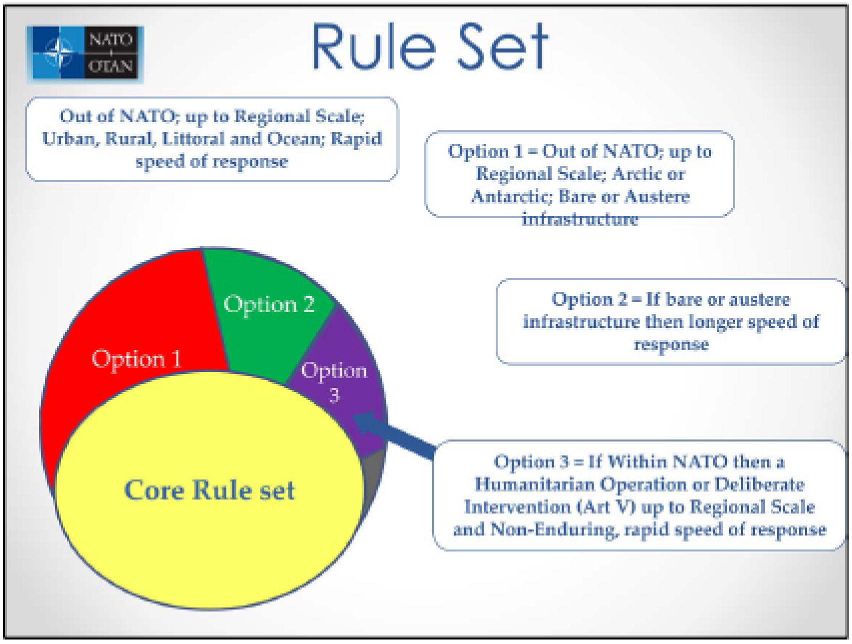
Speaking notes
-By going through a similar process, alternative definitions can be derived
-Each option represents a different branch of the tree



Speaking notes
- Core set + Opt 1 = 79%



Speaking notes
- Core set + Opt 1 + Opt 2= 92%

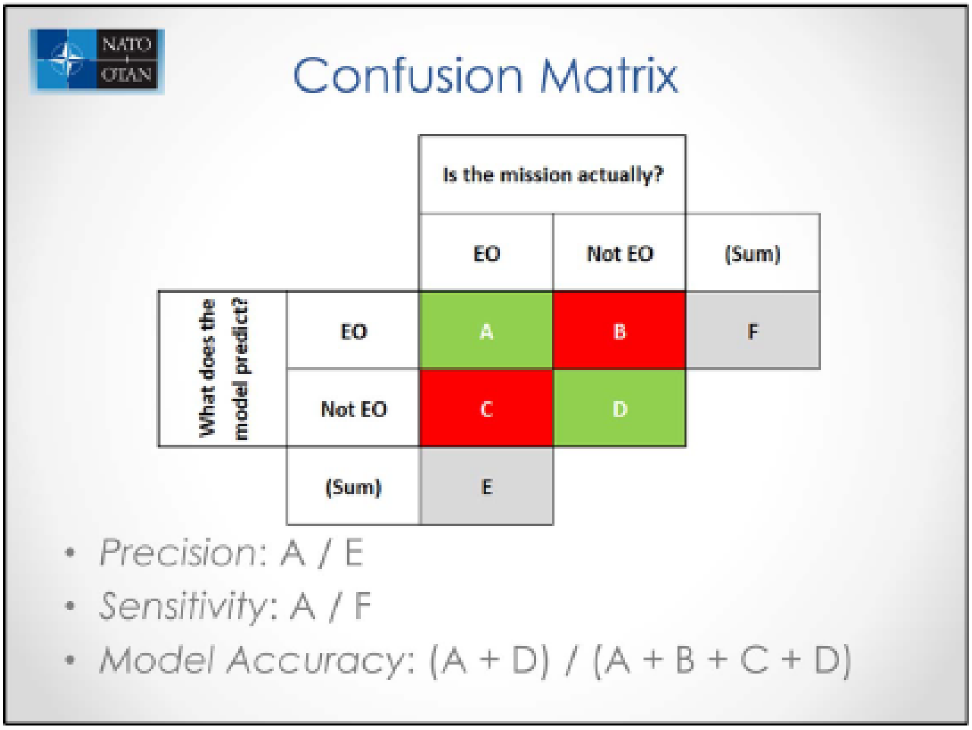


Speaking notes

- Opt 3 is OUT of NATO

-Core set + Opt 1 + Opt 2 + Opt 3= 99%

-Core set + Opt1 & 2 can be combined.



Speaking notes

•If operation has particular characteristics, the generic definition will predict if is EO. May or may not be correct

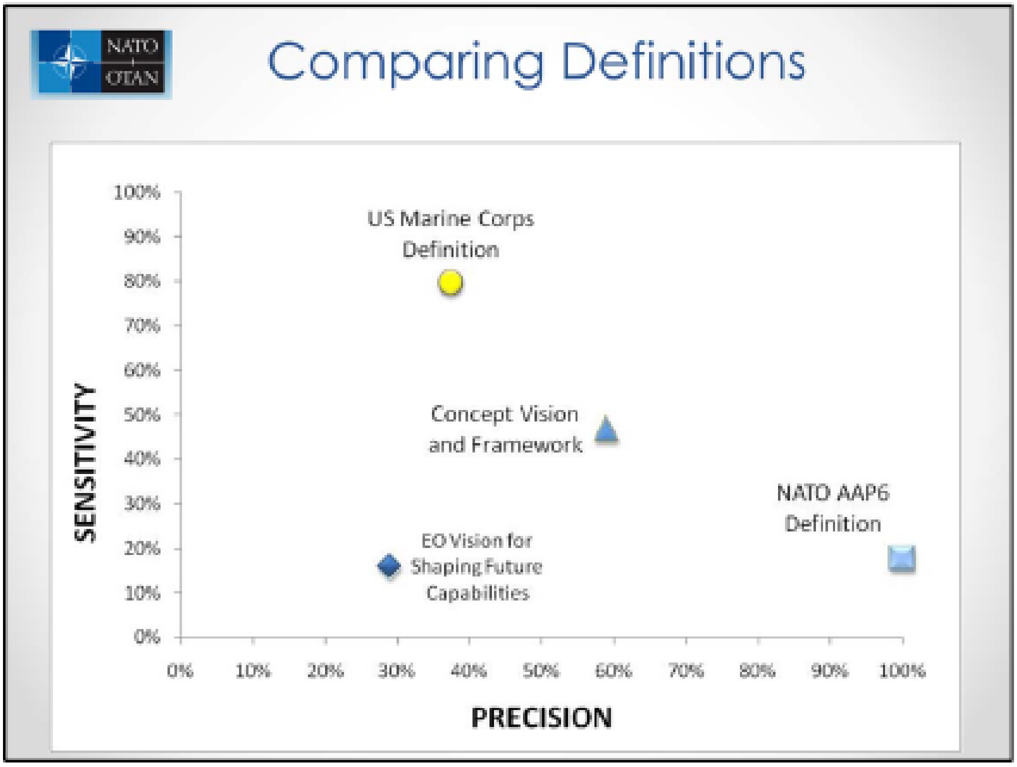
•Want to minimise false results and maximise correct predictions

•Precision - the % of Expeditionary Operations that are covered by the Rule

•Sensitivity - how many operations are mis-classified, e.g. If the rule is that "All EO are Out of NATO" that does not mean that "All endeavours Out of NATO are EO"

•Model Accuracy maximises the correct predictions and minimises the false positives & negatives.

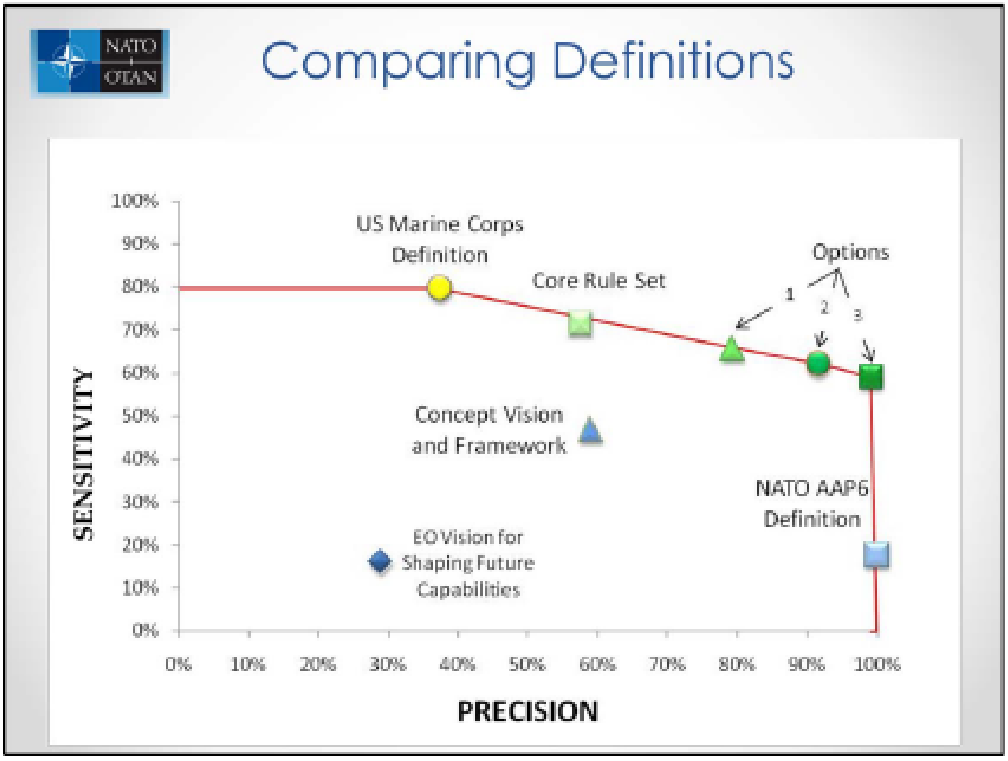
•Can measure existing definitions



Speaking notes

Sensitivity & Precision are formal terms, but easier to think of Sensitivity – ability to avoid mis-classification of EO as not EO or vice-versa; Precision as coverage of all operations identified as NATO EO.

- Current definition – covers nearly everything – but does not discriminate very well
- USMC definition – very sensitive – but misses key operations relevant to NATO
- OCV&F – half way between the two (where we started)
- EO Vision – what the Military Committee agreed to – least useful!



Speaking notes

- Core rule set – better than EO vision – less sensitive (specific) but more precise (coverage) than USMC.
- Options – improve precision coverage at the expense of sensitivity.

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14. Abstract

This study generates case study learning modules to demonstrate the value of analytical methods in various decision-making applications. The intended audience for these modules are non-analysts at the executive and flag officer decision-maker level. Military Operations Research (OR) or Operational Analysis (OA) is defined as the application of scientific methods to assist executive decision-makers, commanders, and their staffs in illuminating key issues related to evaluating alternatives in operational courses of action, logistics support, and procurement of forces, or assessing on-going operations. When applied successfully, OR/OA will almost always result in savings and increased efficiency or effectiveness or both. Knowledge of how the tools and techniques of OR/OA may be applied will help decision makers fully leverage their potential.

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